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CIRRIPEDIA

BY

H. G. STUBBINGS, B.A.(CANTAB.), B.SC.(LOND.)

(Late Scholar of St. Catharine's College, Cambridge)

WITH THIRTY TEXT-FIGURES

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INTRODUCTION.

THE collection of Cirripedia, though small, is of considerable interest, as it comprises, besides five new species and one new variety, many forms that have been taken only once or twice before.

The following is a list of all the species in the collection :

Lepas anserifera Linnæus.
L. anatifera Linnæus.
L. anatifera subsp. *indica* Annandale.
L. hillii (Leach).
Conchoderma virgatum (Spengler).
Pœcilasma kæmpferi Darwin.
P. (*Temnaspis*) *excavatum* Darwin.
P. crassa Darwin.
Dichelaspis tridens Aurivillius.
D. (*Octolasmis*) *nierstraszi* Hoek.
Megalasma minus Annandale.
Oxynaspis aurivillii Stebbing.
Heteralepas (*Paralepas*) *typica* Nilsson-Cantell.
Scalpellum (*Smilium*) *kampeni* Annandale.
Sc. (*Euscalpellum*) *bengalense* Annandale.
Sc. (*E.*) *rostratum* Darwin.
Sc. (*Scalpellum*) *abyssicola* Hoek.
Sc. (*Sc.*) *diota* Hoek.
Sc. (*Sc.*) *elegans* Hoek.
Sc. (*Sc.*) *elongatum* Hoek.
Sc. (*Sc.*) *formosum* Hoek.
Sc. (*Sc.*) *laccadivicum* Annandale.
Sc. (*Sc.*) *lambda* Annandale.
Sc. (*Sc.*) *longius* Annandale.

Sc. (*Sc.*) *minutum* Hoek.
Sc. (*Sc.*) *velutinum* Hoek.
Sc. (*Sc.*) *wood-masoni* Annandale.
Sc. (*Sc.*) *wood-masoni* var. *murrayi* var. nov.
Verruca (*Rostrato-verruca*) *murrayi* sp. nov.
V. (*R.-v.*) *sewelli* sp. nov.
V. (*Verruca*) *capsula* Hoek.
V. (*V.*) *macani* sp. nov.
Balanus (*Megabalanus*) *tintinnabulum* Darwin.
B. (*Balanus*) *trigonus* Darwin.
B. (*B.*) *amphitrite* var. *communis* Darwin.
B. (*Chirona*) *amaryllis* Darwin.
B. (*C.*) *albus* Hoek.
B. (*Solido-balanus*) *ciliatus* Hoek.
B. (*S.-b.*) *thompsoni* sp. nov.
B. (*S.-b.*) *echinoplacis* sp. nov.
B. (*Conopea*) *cymbiformis* Darwin.
B. (*C.*) *navicula* Darwin.
Acasta cyathus Darwin.
Tetraclita porosa var. *communis* Darwin.
Chthamalus stellatus (Poli).

In a few species, chiefly of the genus *Scalpellum*, an attempt has been made to determine the distribution, both geographical and bathymetrical. In the majority of cases the results are disappointing, owing to lack of a sufficient number of records. One or two species, notably *Sc. velutinum* Hoek, are, however, sufficiently well known to enable a distribution map to be drawn up. As far as possible the author has endeavoured to include all the records available in the literature of the species thus mapped. Where there appears to be a possibility of a relationship between two or more species, in a distributional sense, such species have been shown together on a single map, *e. g. Scalpellum elongatum* together with *Sc. novæ-zelandiæ*, and *Sc. albatrossianum* with *Sc. formosum*.

Suborder LEPADOMORPHA Pilsbry 1916.

This suborder is represented by seven genera, twelve species and one subspecies. All, except *Oxynaspis aurivillii* Stebbing and *Heteralepas typica* Nilsson-Cantell, have been recorded previously from the Indian Ocean.

Genus LEPAS Linnæus.

Four species of this genus have previously been recorded from the Indian Ocean, chiefly from the Bay of Bengal and the Indian Coast of the Arabian Sea. These are :

Lepas anserifera Linnæus.
L. anatifera Linnæus subsp. *indica* Annandale.
L. tenuivalvata Annandale, and
L. fascicularis Ellis and Solander—from the Malay Archipelago.

Of the fourth species, Annandale remarks that it has not actually been recorded from the Indian Ocean, but as it occurs in the Malay Archipelago he considers it highly probable that it occurs in the Indian Ocean, at least in the Bay of Bengal, into which the ocean currents would carry it, especially during the N.E. monsoon period. Four other species, namely :

Lepas hillii (Leach) from the South Seas (A. Menzies) and Port Stephen, Australia (Darwin),

L. pectinata Spengler, according to Darwin a common tropical form,

L. australis Darwin
L. testudinata Aurivillius } both from the Southern Ocean,

have not hitherto been recorded from the Indian Ocean ; but among the specimens of *Lepas* in the collection are two which I have assigned to *L. hillii* (Leach). As, however, they were removed from the ship's hull in Mombasa it is not possible to give their place of origin definitely, though it is certain that they came from either the Arabian Sea, or, less probably, the Red Sea, as the ship had been only a comparatively short time in this latter area.

The specimens of this genus in the present collection belong to three species, namely, *L. anserifera* Linnæus, *L. anatifera* Linnæus and its subspecies *indica* Annandale, and *L. hillii* (Leach).

Lepas anserifera Linnæus.

Lepas anserifera, Linnæus, 1788, p. 3210.
Lepas anserifera, Darwin, 1851, p. 81, pl. i, fig. 4.
Lepas anserifera, Annandale, 1909*a*, p. 75, text-fig. 2.

Occurrence.—(i) Sta. 25, Gulf of Aden, surface ; numerous specimens attached to a clump of *Sargassum*, which also harboured various other small invertebrates.

(ii) Sta. 41, South Arabian Coast, surface ; 2 specimens, one badly crushed, attached to the frond of a piece of *Sargassum*.

(iii) From the ship's side in Mombasa Harbour on January 3rd, 1934 ; 4 specimens, somewhat larger, and mature though not of full size. These specimens contain large masses of eggs.

Remarks.—All the specimens from Sta. 25 are immature. One contained two small parasitic Isopods, apparently a ♂ and ♀ of a species of Bopyrid, of which the larger, and presumably ♀, specimen appears to be immature, as it still shows considerable segmentation and retains many of the normal isopod characters.

Lepas anatifera Linnæus.

Lepas anatifera, Linnæus, 1788, p. 3211.
Lepas anatifera, Darwin, 1851, p. 73, pl. i, fig. 1.
Lepas anatifera, Jennings, 1914, p. 288, text-figs. 1–1*c*.

Occurrence.—Sta. 39, Gulf of Aden, surface ; numerous very young specimens attached to a floating cuttlefish " bone ".

Remarks.—The majority of the specimens are too small for specific determination, but the larger ones quite clearly belong to *L. anatifera* Linnæus. None of them has the row of square depressions on the capitulum.

Lepas anatifera subsp. *indica* Annandale.

Lepas anatifera subsp. *indica*, Annandale, 1909*a*, p. 76, fig. 4.

Occurrence.—Ship's side, Mombasa Harbour, 1 specimen.

Remarks.—The specimen is considerably larger than the other specimens of *L. anatifera*, though probably not full-grown, and bears a row of depressions on the capitulum. It agrees in external structure very closely with the form described as the above subspecies.

Lepas hillii (Leach).

Lepas hillii, Darwin, 1851, p. 77, pl. i, fig. 2.
Lepas hillii, Nilsson-Cantell, 1928, p. 15, text-fig. 6.

Occurrence.—To this species I have assigned 2 specimens, one large and the other small, removed from the ship's hull in Mombasa Harbour.

Genus CONCHODERMA Olfers.

This genus is represented in the collection by numerous small, though mature, specimens of *C. virgatum* (Spengler).

Conchoderma virgatum (Spengler).

Conchoderma virgatum, Darwin, 1851, p. 146, pl. iii, fig. 2, pl. ix, fig. 4.
Conchoderma virgatum, Annandale, 1909*a*, pp. 80–83 ; 1909*c*, p. 295.

Occurrence.—The bulk of the examples in the collection were scraped off the ship's side in Mombasa Harbour at the beginning of January, 1934.

Remarks.—The specimens average between 20 and 25 mm. in length, including the peduncle. They are thus by no means full grown, but that they are sexually mature is fully demonstrated by an immense mass of eggs within a specimen selected at random and dissected. The ship's hull had been scraped before the expedition sailed in the previous September, so it is evident that this species is capable of reaching maturity in three to four months, although it will then be far short of its full size. Annandale (1909*c*) records an instance of specimens of *C. virgatum* var. *hunteri* growing on a buoy in the Bay of Bengal, which had attained a capitular length of 15 mm. in the short space of eight days. The buoy was placed in the sea clean and taken up at the end of that time. There is thus no doubt that *Conchoderma virgatum* is a barnacle that develops very rapidly.

Two other examples of this species in the collection purport to come from stations 87 and 121. From the fact that they are both broken and that each has a layer of red material—presumably red-lead paint—attached to the base of the peduncle, it seems certain that these specimens were also scraped off the ship by the net, as it was being hauled, at these particular stations.

A number of the specimens are coloured a rather deep green. This is most certainly due to the fact that the specimens were stored in alcohol with a considerable amount of a filamentous green alga, also from the hull of the ship, and not to any natural variation in the colour of the species itself.

Genus POECILASMA Darwin.

Three species of this genus were obtained—*P. crassa* Darwin, *P. excavatum* Hoek and *P. kæmpferi* Darwin ; all were attached to Crustacea.

The genus *Pœcilasma* Darwin was split up by Pilsbry (1907*a*) into two genera—*Trilasmis*, for *T. eburneum* Hinds, the original type of the genus as founded by Hinds (1844), and *Pœcilasma* s. str., which he again subdivided into the subgenera *Temnaspis* and *Pœcilasma* s. str. Broch (1931) confirmed this division by a study of the development of the capitulum in young specimens. The subgenera are differentiated on the form of the capitular valves, *Pœcilasma* s. str. having the scutum entire, and *Temnaspis* the scutum divided from the very beginning. This character distinguishes *Temnaspis* from the "*Octolasmis*" group of *Dichelaspis*, in which the scutal division is secondary and due to the imperfect calcification of the valve. Both subgenera possess terga. The genus *Trilasmis* includes such species of *Pœcilasma* (*sensu lato*) as are devoid of terga, *e. g. Pœcilasma eburnea* (Hinds).

In a slightly later paper, Pilsbry (1907*b*) further restricted *Pœcilasma* by separating off those species, *e. g. P. carinatum* and *P. rectum*, in which the basal portion of the carina was enlarged. These he transferred to the genus *Megalasma*, erecting for them the new subgenus *Glyptelasma*.

Adopting this division of the genus into subgenera, *Pœcilasma* s. str. is represented by *P. kæmpferi* Darwin and *P. crassa* Darwin, and *Temnaspis* by *P. excavatum* Hoek.

Pœcilasma (*Pœcilasma*) *kæmpferi* Darwin. (Fig. 1.)

Pœcilasma kæmpferi, Darwin, 1851, p. 102, pl. ii, fig. 1 ; Annandale, 1908, pl. iii, fig. 1 ; 1909*a*, p. 90, pl. vii, text-fig. 8.
Pœcilasma (*Pœcilasma*) *kæmpferi*, Nilsson-Cantell, 1921, p. 254, text-fig. 46.
Pœcilasma dubium, Hoek, 1907, p. 6, pl. i, figs. 2–4, pl. x, figs. 1*a–d*.

Occurrence.—Sta. 106, Zanzibar Area, depth 217 metres, numerous examples attached to the carapace of a large specimen of the crab *Echinoplax pungens* Wood-Mason.

Remarks.—The examples are referable to Race II of Annandale or *P. dubium* Hoek. According to Annandale the race occurs in the Gulf of Manaar and the Malay Archipelago ; its capture off the African coast thus extends its area of distribution across the whole width of the Indian Ocean.

The species, in one or more of its five races, as given by Annandale (1909*a*), appears to be fairly generally distributed in tropical and sub-tropical seas. It has been taken as far North as the 40th parallel (in Japan) and as far South as Tasmania (Broch, 1931), but apart from these two records the main distribution of the species seems to be nearer the equator, the southern limit at about 10° S. and the northern at about 30° N., though within this belt the species has not yet been recorded from either the Pacific Ocean or the southern part of the Indian Ocean.

A single cypris larva (Fig. 1) was found attached to one of the specimens. It is tentatively referred to *P. kæmpferi*, though it is impossible definitely to assign it to any species. Three species of *Pœcilasma* were attached to the particular specimen of *Echinoplax pungens* Wood-Mason from which it was obtained. The specimens of *P. kæmpferi*, however, far outnumbered the other two species (*P. excavatum* and *P. crassa*) together. The cypris shows well-developed cirri and cypris eyes ; the peduncle is

differentiated but lies inside the shell and the small attaching tentacles are quite distinct. The mantle of the adult barnacle is visible and the scutum can be distinguished, but neither of the other two valves is visible.

Fig. 1.

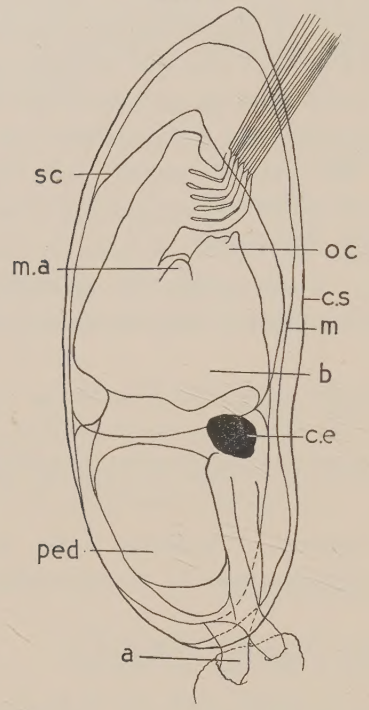
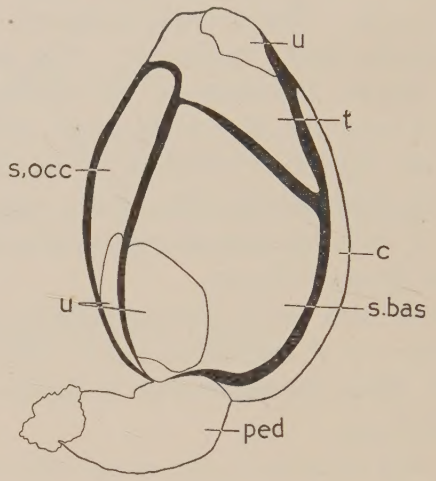


Fig. 2.



Text-fig. 1.—Cypris larva of *Pœcilasma* sp., × 48. *a.*, fixing antennæ. *b.*, body of larva. *c.e.*, cypris eye. *c.s.*, cypris shell. *m.*, mantle. *m.a.*, mouth appendages. *o.c.*, labrum. *ped.*, peduncle. *sc.*, outline of scutum.

Text-fig. 2.—*Dichelaspis tridens* Aurivillius. *c.*, carina. *ped.*, peduncle. *s.bas.*, *s.occ.*, basal and occludent portions of scutum. *t.*, tergum. *u.*, umbones of the valves.

Pœcilasma (*Pœcilasma*) *crassa* Darwin.

Pœcilasma crassa, Darwin, 1851, p. 107, pl. ii, fig. 3.
Pœcilasma (*Pœcilasma*) *crassa*, Barnard, 1924, p. 52.

Occurrence.—Sta. 106, Zanzibar Area, depth 217 metres; 3 specimens, attached to the same specimen of *Echinoplax pungens* Wood-Mason as the previous species.

Remarks.—All the specimens are small, the largest having a total length of 7·4 mm., of which the capitulum occupies 5·5 mm. In all the specimens the tergum is exceedingly small, and only slightly wider than the upper part of the carina, or as wide as the lower part of that valve.

Subgenus Temnaspis Fischer.

Pœcilasma (*Temnaspis*) *excavatum*, Hoek.

Pœcilasma excavatum, Hoek, 1907, p. 10, pl. i, figs. 5–10.

Occurrence.—(i) Sta. 106, Zanzibar Area, depth 217 metres; about 30 specimens attached to the crab *Echinoplax pungens* Wood-Mason with the two preceding species, a species of *Balanus* and a species of *Verruca*.

(ii) Sta. 144, Gulf of Aden, on the Arabian side, depth 220 metres; very numerous specimens on the Palinurid *Puerulus angulatus* (Spence-Bate).

Remarks.—The specimens are all young, mostly with a capitular length of less than 4·0 mm.

Genus DICHELASPIS Darwin.

Under the above genus are included the two genera *Dichelaspis* Darwin and *Octolasmis* Gray, as redefined by Pilsbry (1907*b*), and adopted by Krüger (1911) and Stebbing (1910). *Octolasmis* has been separated from *Dichelaspis* s. str. as a distinct genus on account of the calcified portion of the valves and the forked basis of the carina. *Dichelaspis* (s. str.) has the valves more strongly calcified and the basis of the carina disc-like. This genus is largely found externally on crabs, etc., whereas the species of *Octolasmis* live as commensals on the gills of crabs or Macrura or on the walls of the branchial chamber (Pilsbry, 1907*b*). Otherwise both groups of species are very similar, and it seems needless to create separate genera on the above small differences. Accordingly I have here regarded *Octolasmis* merely as a subgenus of *Dichelaspis*, distinguished by the above-mentioned differences of morphology and habitat.

In the present collection *Dichelaspis* (*sensu lato*) is poorly represented, only one species of each of the two subgenera having been found.

Subgenus Dichelaspis Darwin.

Dichelaspis (*Dichelaspis*) *tridens* (Aurivillius). (Fig. 2.)

Pœcilasma tridens, Aurivillius, 1894, p. 14, pl. i, fig. 13, pl. vi, fig. 12, pl. viii, figs. 13, 29.
Dichelaspis occlusa, Lanchester, 1902, p. 373, pl. xxxv, figs. 6, 6*c*.
Octolasmis tridens, Barnard, 1924, p. 57.

Occurrence.—Sta. 106, Zanzibar Area, depth 217 metres; 1 specimen attached to the undersurface of the carapace of a species of *Ibaccus*, probably *I. verdi* Spence-Bate, near the maxillipeds.

Remarks.—*Dichelaspis occlusa*, as described by Lanchester (1902), seemed effectually to bridge the gap between the Darwinian genera *Dichelaspis* and *Pœcilasma* by linking the more complete Dichelaspids with the less complete species of *Pœcilasma*, such as *P. tridens* Aurivillius. The inclusion of Lanchester's species with *P. tridens* and the transference of the latter to *Dichelaspis* tended to define the two genera more clearly by excluding the species with reduced valves from *Pœcilasma*. At the same time it did not militate against the possibility of their near relationship, as several nearly " complete " species of *Dichelaspis* are known.

The present specimen (Fig. 2) is exceptionally complete, being rather more so than the form described by Lanchester (1902) as *D. occlusa*. The notch in the tergum for the basal segment of the scutum is filled up so that the valve is triangular except for the deep notch for the reception of the occludent segment of the scutum. The occludent margin of the tergum is strongly bowed and almost angular, giving the valve a truncated and quadrilateral appearance. The specimen thus approaches very near to a *Pœcilasma* of the *Temnaspis* (Fischer, 1884) type with complete, unreduced tergum, but is still readily recognizable as a *Dichelaspis* by the projection of the carina between the terga.

Thus *D. tridens* now serves to link the complete forms of *Dichelaspis* with those with reduced valves, instead of illustrating a possible case of parallel reduction of the valves in the two genera *Dichelaspis* and *Pœcilasma*.

Subgenus Octolasmis Gray.

The other species of *Dichelaspis* in the collection belongs to this subgenus.

Dichelaspis (*Octolasmis*) *nierstraszi* Hoek.

Dichelaspis nierstraszi, Hoek, 1907, p. 21, pl. ii, figs. 1–7.
Octolasmis nierstraszi, Nilsson-Cantell, 1921, p. 268.

Occurrence.—(i) Sta. 27, Gulf of Aden, depth 37–92 metres ; 1 specimen, attached to a finely-branched species of Antipatharian, which also bore numerous specimens of *Oxynaspis aurivillii* Stebbing.

(ii) Sta. 146, Maldive Area, depth 37 metres ; 2 specimens on an Antipatharian.

Remarks.—According to Annandale (1910*b*), the species is common in the Malay Archipelago, where the original specimens were obtained by the " Siboga " Expedition, and has been recorded from the Bay of Bengal and the coast of Portuguese East Africa. It has not previously been recorded as far north as the Gulf of Aden, in the western Indian Ocean. The species appears to be essentially an inhabitant of shallow water. Of nineteen localities recorded by the " Siboga " Expedition only two were over 100 metres deep, the majority being from less than 60 metres.

Genus MEGALASMA Hoek.

The genus *Megalasma* is represented by specimens from three localities in the Arabian Sea ; all belong to the subgenus *Megalasma* s. str., the subgenus *Glyptelasma* being unrepresented. The latter subgenus appears to be uncommon in the Indian Ocean, where a single species, *Megalasma* (*Glyptelasma*) *hamatum* Calman (1919, p. 370), has been found once only in the Zanzibar region. It occurs abundantly, however, in the East Indies and in Australian waters and has been found frequently in the Atlantic Ocean.

Only three examples are of sufficient size for definite identification and only one species is represented, namely,

Megalasma (*Megalasma*) *minus* Annandale.

Megalasma striatum subsp. *minus*, Annandale, 1906, p. 399 ; 1908, pl. i, fig. 8.
Megalasma minus and *M. bellum*, Pilsbry, 1907*c*, pp. 409–414, text-figs. 1–7.
Megalasma minus race I and II, Annandale, 1909*a*, p. 96.
Megalasma minus, Calman, 1919, p. 361.

Occurrence.—(i) Sta. 109, Zanzibar Area, depth 641 metres ; 1 large specimen and several very small ones, attached to a small dead Cidarid covered with mucoid matter mixed with Polychæt tubes, hydroids, etc.

(ii) Sta. 115, Zanzibar Area, depth 690 metres ; 1 large specimen and three small ones, associated with a new species of *Verruca*, on the spines of a Cidarid.

(iii) Sta. 152, Maldive Area, depth 609–915 metres; 1 large dead specimen from the dried bottom sample collected with the dredge.

Remarks.—Two of the large specimens have the scutum more than twice as long as broad, but in the third (from Sta. 115) the length is slightly less than twice the greatest diameter. In this the specimen agrees with one recorded by Calman (1919, p. 362), and, as that author remarks, breaks down the boundary between *M. minus* Annandale and *M. bellum* Pilsbry. There appears to be little or no doubt that the differences in the exhaustive list given by Pilsbry (1907*c*) are all differences of variation and are not of specific value.

Genus OXYNASPIS Darwin.

Oxynaspis, Darwin, 1851, p. 133, pl. iii.
Oxynaspis, Aurivillius, 1894, p. 38.

Darwin instituted this genus, though unwillingly, for the reception of a single species of barnacle found growing on an Antipatharian and provided with spines on the capitulum. Since the publication of Darwin's work eight new species and several subspecies have been described. There are now nine "good" species of *Oxynaspis*, namely, in chronological order:

Oxynaspis celata Darwin, 1851.
O. patens C. W. S. Aurivillius, 1894.
O. aurivillii Stebbing, 1900.
O. indica Annandale, 1909*a*, 1914.
O. bocki Nilsson-Cantell, 1921.
O. terræ-novæ Totton, 1923.
O. pacifica Hiro, 1931.
O. connectens Broch, 1931.
O. pulchra Nilsson-Cantell, 1934.

All, except the last two, occur on Antipatharian corals.

These species show a considerable variation in the degree of calcification of the valves. In Darwin's species, *O. celata*, the capitulum was completely covered by the valves, the scutum being complete and trapezoid. The carina and tergum always remain well developed throughout the genus. Annandale's species, *O. indica*, is very similar to *O. celata*, in the shape and amount of calcification of the scutum. *O. connectens*, one of the two species not occurring on Antipatharia, also has complete valves, which are, moreover, very much thicker than in the species epizoic on Antipatharia. This may perhaps be correlated with the fact that the capitulum is not protected by the overgrowth of the tissues of the coral, and so has to withstand the full effects of erosion by the water and of attacks by parasites. In *O. pacifica* Hiro the first stage in reduction is seen: there is a large gap between the carina and the carinal margin of the scutum.

O. patens Aurivillius shows an increase of this reduction, in the emargination of the whole carinal-basal half of the valve, so that the scutum becomes almost triangular with the apex downwards. This process of reduction is brought to a conclusion, as far as is known, in *O. bocki* Nilsson-Cantell, in which the scutum is reduced to a long process along the occludent edge of the capitulum with a median umbo from which two short processes project towards the carina.

The species *O. aurivillii* Stebbing has the scutum roughly reduced to the shape of a trapezium by reduction of the occludent basal angle and the upper carinal (carino-tergal) angle. Reduction has thus occurred in a different manner in this species to that in the other eight. The young *O. aurivillii*, as figured by Stebbing (1900) in the original description, has an irregular strap-like scutum, resembling the scutum of *O. bocki*, but without the short lateral processes.

Over the question of the capitular spines there has been considerable controversy ever since the redescription of the genus by Aurivillius (1894). Darwin definitely stated that the spines in *O. celata* were part of "the muricated bark of the Antipathes". Aurivillius, however, was inclined to believe that the spines were wholly formed in the chitin of the cirripede, as they appeared to be in his new species *O. patens*. Stebbing (1900) stated that in a new species described by him (*O. aurivillii*) the spines were clearly part of the cirripede chitin. Below the species are listed with the varying opinions of different authors as to the origin of the spines:

Species.	Origin of spines.	
	Cirripede.	Antipatharian.
Oxynaspis celata . . .	Aurivillius, 1894 .	Darwin, 1851. Broch, 1922.
O. patens	Aurivillius, 1894 .	..
O. aurivillii	Stebbing, 1900 .	..
	Nilsson-Cantell, 1921 .	..
O. indica	Annandale, 1909*a* .	Annandale, 1914.
O. bocki	Nilsson-Cantell, 1921 .	..
O. terræ-novæ	Totton, 1923 .	Totton, 1923.
O. pacifica	.. .	? Hiro, 1931.
O. connectens	Broch, 1931 .	..
O. pulchra	Nilsson-Cantell, 1934 .	..

The Antipatharian origin of the spines in Hiro's species *O. pacifica* is queried, as this author remarks in his diagnosis of the species that both capitulum and peduncle are "covered by chitinous horny bark". His use of the term "bark" suggests that he considers this layer to be of Antipatharian origin.

The general consensus of opinion is thus in favour of a cirripede origin for the spines on the capitulum and peduncle, the exceptions being Darwin, who knew but the one species and admitted the bad state of preservation of his specimens, and Annandale, who on the evidence afforded by a single young specimen altered his opinion in favour of an origin from the coral skeleton. Of this specimen he says (Annandale, 1914): "In a young specimen . . . the antipatharian has produced a flat, spiny growth over the valves, and from this growth normal branches are actually given off at the tip of each tergum of the cirripede, reaching a length of several millimetres." He adds, "There can, therefore, be no doubt that the external covering of the barnacle is produced, not by the animal itself, but by the organism to which it is attached". He thus neglects the possibility of a dual origin for the spines.

However, a species brought back from the Pacific by Mortensen and described by Broch (1931) under the name of *O. connectens* would seem to settle the question finally. This species was found attached to a siliceous sponge, but had the usual spiniferous

cuticle. Nilsson-Cantell's species *O. pulchra* (Nilsson-Cantell, 1934) likewise has spines, though it was obtained from a telegraph cable. Broch temporized by saying that the spines, in the Antipatharian commensals, are of a dual nature, chitinous spines being produced by the barnacle, as was stated by Annandale (1909*a*) and as is shown by *O. connectens* and *O. pulchra*, and another layer over the spines being produced by the Antipatharian, as was also shown by Annandale in the passage quoted above, and is demonstrated by the fact that the coral flesh may frequently overgrow the barnacle and produce polyps on it, as may be seen in several of the specimens of *O. aurivillii* in the present collection. Broch (1922) also figures a specimen of *O. celata* var. *japonica* showing polyps on the capitulum of the barnacle. Broch evidently had in mind the possibility of the dual nature of the spines when he discussed the question in 1922. He does not, however, appear to have seen Annandale's (1914) note on *O. indica*, as he does not mention it, but only that author's earlier and opposite view (Annandale, 1909*a*).

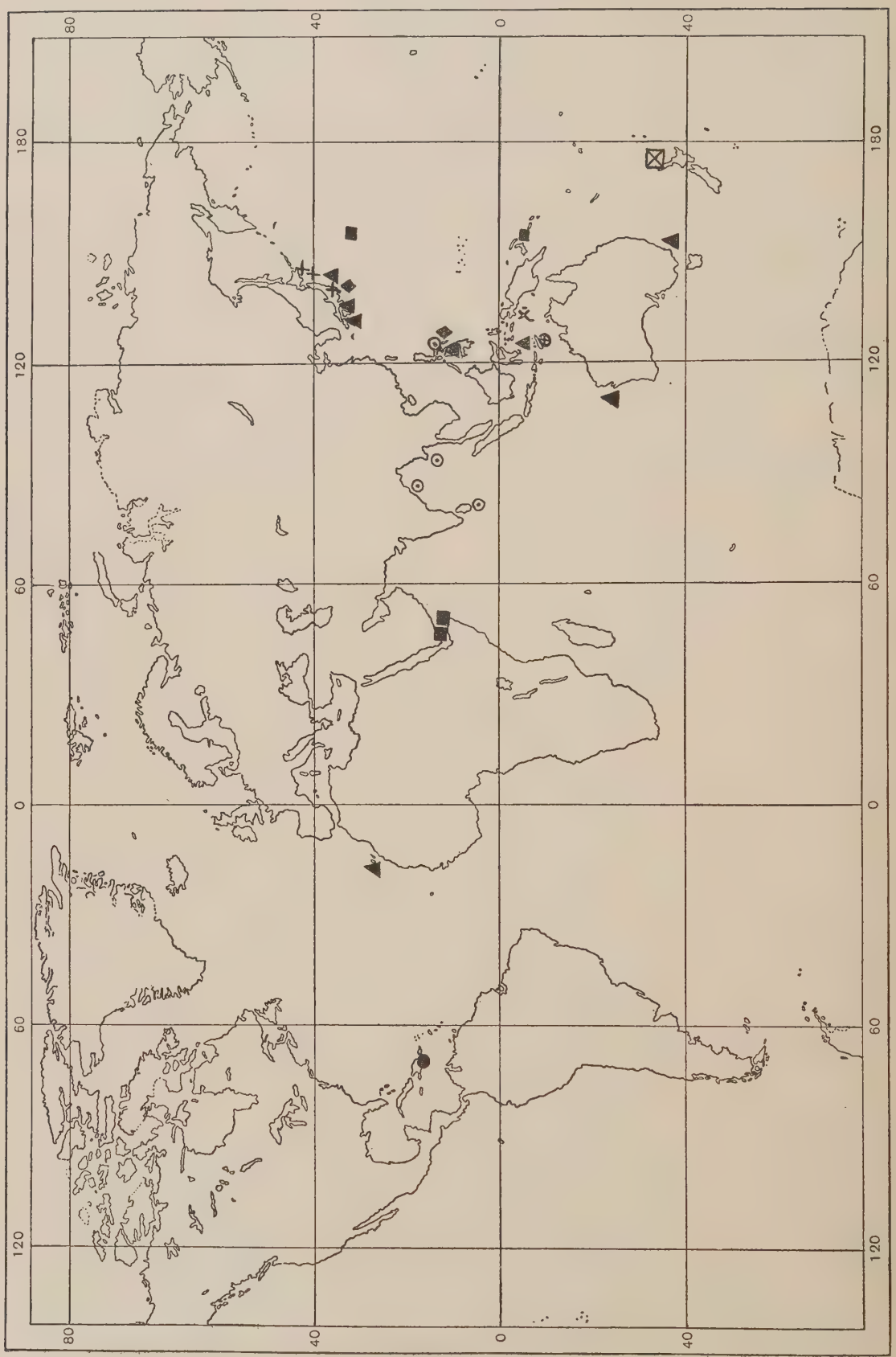
Taking the evidence afforded by all the known species, there is now little reason to doubt that Broch's statement, that the spines have a dual origin from the cuticle of the cirripede and from the overlying skeleton of the Antipatharian, is correct for those species epizoic on Antipatharians.

Distribution of the Species of *Oxynaspis*. (Fig. 3).

In the following list the various records of the different species have been collected together :

Oxynaspis celata Darwin	(1) Madeira	(Darwin, 1851).
	(2) West Australia, Golo Island, Kiushiu	(Nilsson-Cantell, 1921).
	*(3) Japan, 33° 41′ N., 128° 50′ E. Nagasaki (var. *japonica*), 38° 12′ S., 149° 40′ E. (forma *novæ-zelandiæ*)	(Broch, 1922).
O. patens Aurivillius	(1) Antilles Sea near Anguilla Island	(Aurivillius, 1894).
O. aurivillii Stebbing	(1) New Britain	(Stebbing, 1900).
	(2) Bonin Island, Japan	(Nilsson-Cantell, 1921).
	(3) Arabian Sea, new locality.	
O. indica Annandale	(1) Off Akyab, Burma, Off Orissa coast, South of Ceylon	(Annandale, 1909*a*).
	(2) Off Jolo Golo	(Broch, 1931).
O. bocki Nilsson-Cantell	(1) Golo Island, (2) Kiushiu	(Nilsson-Cantell, 1921).
O. terræ-novæ Totton	(1) 7 miles E. of Cape North, New Zealand	(Totton, 1923).
O. pacifica Hiro	(1) Japan, Seto, Toba, Misaki	(Hiro, 1931).
O. connectens Broch	(1) Kei Islands, 5° 37′ S., 132° 23′ E.	(Broch, 1931).
O. pulchra Nilsson-Cantell	(1) Singapore, 10° 27′ 46″ S., 126° 4′ 30″ E.	(Nilsson-Cantell, 1934).

* Hiro, 1936, Japan J. Zool. Tokyo. VI, 4, p. 623, records *O. celata* from Buton Is. S.E. of Celebes.



TEXT-FIG. 3.—Distribution of the species of *Oxynaspis*.

Outside the Western Pacific, Bay of Bengal and Arabian Sea this genus has been recorded from only two localities : *O. celata* is known from Madeira and *O. patens* from the Antilles Sea. The genus is thus almost entirely confined to the east. As far as is known, the northern range seems to be about the 45th parallel. Specimens have been taken in approximately this latitude off Japan and Madeira. Except for the two Australian records of *O. celata* Darwin and that of *O. terræ-novæ* Totton off New Zealand, the southern limit of the genus is about 10° S.

The parallels of longitude 50° E. and 160° E. approximately give the western and eastern boundaries of the main distributional area. Seven species occur within this comparatively small area and six are confined to it, the only exceptions being those mentioned above, namely, *O. patens* Aurivillius, and *O. terræ-novæ* Totton, which was found rather farther to the East. *O. celata* Darwin may well prove to be of world-wide distribution either in its typical form or in one of its varieties *japonica* and *novæ-zelandiæ*.

At present no records for the genus have been obtained from the Indian Ocean proper, the Pacific Ocean east of longitude 160° E., the South Atlantic or Southern Ocean. In the northern hemisphere no records have been obtained in either the Pacific or the Atlantic north of Kiushiu and Madeira respectively ; but, as regards the Pacific, this may well be due to the paucity of our knowledge of the sea-bottom in this area. The lack of species of *Oxynaspis* in the above-mentioned areas is evidently not connected with the distribution of the Antipatharia, as species of this latter group have been obtained, and it seems probable that subsequent search will reveal species referable to *Oxynaspis* in many of these hitherto " barren " areas.

Oxynaspis aurivillii Stebbing. (Fig. 4.)

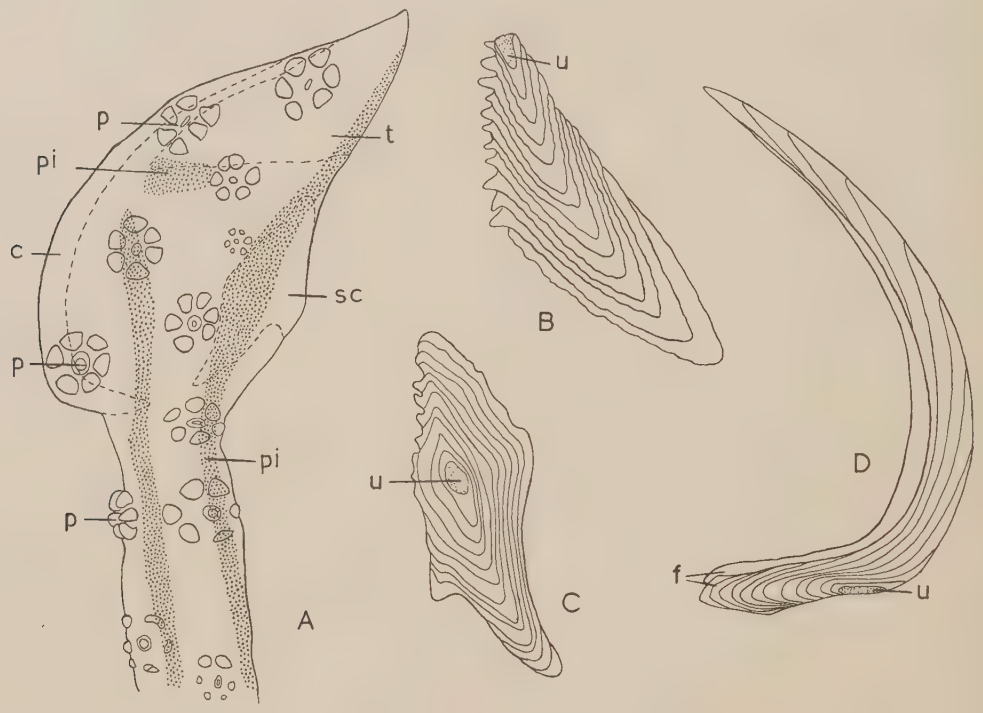
Oxynaspis aurivillii, Stebbing, 1900, p. 675, pl. lxxiv *c*.
Oxynaspis aurivillii, Nilsson-Cantell, 1921, p. 231, pl. 3, fig. 2, text-fig. 39.

Occurrence.—(i) Sta. 27, Gulf of Aden, depth 37–92 metres ; numerous specimens. (ii) Sta. 35, Gulf of Aden, depth 453 metres ; numerous specimens. Nearly all were attached to a finely-branched, bushy species of Antipatharian, but a few from Sta. 35 were attached to a stout, sparsely-branched species.

Remarks.—The specimens agree fairly closely with Stebbing's description as modified by Nilsson-Cantell. Neither author, however, mentions the pectination of the occludent margin of the tergum and of the upper part of the same margin of the scutum. This pectination (Fig. 4 B, C) occurs in both young and adult forms, though in the smaller individuals it is not very well developed. The pectinations seem to be exaggerated crenations caused by successive growth-rings, and appear to get more irregular with each successive growth-ring.

In Stebbing's figure the organism has a patch of pigment immediately below the inferior angle of the tergum and two lines of pigment beginning in the peduncle, one running up the carinal margin and the other up the occludent side of the capitulum, interrupted by the base of the scutum and running up the inside of that valve as far as the umbo. The specimen figured by Nilsson-Cantell appears to have a small pigment patch below the scutum and a larger patch lower down on the peduncle. The present specimens closely resemble in pigmentation Nilsson-Cantell's photograph of *O. bocki*, having an occludent vertical band of pigment and a second vertical band running nearly

up the middle of the peduncle and capitulum (as seen in side view), with a small transverse patch below the tergum. In other respect, however, they do not resemble *O. bocki*, but agree with *O. aurivillii*, to which species I have assigned them.



TEXT-FIG. 4.—*Oxynaspis aurivillii* Stebbing. A, Individual overgrown with polyps of the Antipatharian. B, Tergum. C, Scutum. D, Carina. All × c. 18. *c.*, carina. *f.*, furca of carina. *p.*, polyps of Antipatharian. *pi.*, pigment stripes. *sc.*, scutum. *t.*, tergum. *u.*, umbones of valves.

Genus HETERALEPAS Pilsbry.

This genus is represented by one species :

Heteralepas (*Paralepas*) *typica* Nilsson-Cantell.

Heteralepas (*Paralepas*) *typica*, Nilsson-Cantell, 1921, p. 250, text-fig. 45, pl. iii, fig. 3.

OCCURRENCE.—Sta. 109, Zanzibar Area, depth 627 metres ; 18 specimens attached to broken and detached sea-urchin spines.

REMARKS.—The specimens vary somewhat in size, the dimensions of extreme and average specimens being shown in the following table :

Specimen.	Total length. (mm.)	Capitular length. (mm.)	Capitular breadth. (mm.)
Largest . . .	9·0 .	4·5 .	2·5
Smallest . . .	3·0 .	1·5 .	1·0
Average . . .	6·5 .	3·5 .	2·5

The specimens are not more than half the size of the type-specimen. They agree fairly closely both in general form and in the structure of the appendages with the

published description. The following table gives comparative figures for the number of segments in the appendages for one of the present specimens and for the type (figures quoted from Nilsson-Cantell, 1921).

Specimen and size.	I.	II.	III.	IV.	V.	VI.	Caudal appendages.
John Murray specimen :							
Length of capitulum 4·5 mm. ; length of peduncle 3·0 mm.	7 7	12 13	14 15	15 16	13 15	14 13	12 (10)
Type-specimen :							
Length of capitulum 15·0 mm. ; length of peduncle 12·5 mm.	7 8	12 13	17 18	.. 19	19 19	18 18	10

The small differences in the number of segments, etc., can doubtless be put down to variation and the very immature condition of the specimens. It is remarkable that the first and second cirri have already attained their full segmentation, whereas the remainder are still from three to six segments short of the number in the adult animal. The number of segments in the caudal appendages seems to vary somewhat, regardless of the age of the individual. Of two specimens examined, one had ten segments in the appendages—as many as the much larger type-specimen—whereas the other, of about the same size, had two more than this, namely twelve. Another difference from the type, probably worthy of note, is the reduction in size of the two spines immediately below the large upper spine on the edge of the first maxilla.

Genus SCALPELLUM Leach.

As would appear to be usual in a collection of deep-sea Cirripedia, the bulk of the specimens in the present collection belong to the above genus in its widest sense, no less than fourteen different species having been obtained.

Hitherto the species of *Scalpellum* known only from Indian Seas have been classified either as species of *Smilium* or *Scalpellum* s. str.

The classification of the scalpelliform barnacles here adopted is essentially that published by Pilsbry (1908) and based upon the combination of the better features of that author's earlier paper (1907*b*) and Hoek's (1907) report on the " Siboga " material, except as regards the status to be accorded to the several divisions. Pilsbry ranks the groups *Calantica* Gray, *Smilium* Gray, *Euscalpellum* Hoek and *Scalpellum* Leach as full genera. In the present report the view of Nilsson-Cantell is adhered to and these divisions are given subgeneric value only. The diagnoses of these four subgenera are given by Nilsson-Cantell (1921, pp. 170, 174), and need not be repeated here. Following Pilsbry (1908), the subgenus *Scalpellum* s. str. is further subdivided into two groups thus :

(*a*) Infra-median latus large, pentagonal or with rounded angles, not constricted, and with the umbo varying from submedian to basal or on the rostral border, but never apical . . . . . group *Scalpellum*.

(*b*) Infra-median latus smaller than the other latera, triangular, constricted medianly or irregular . . . . . group *Arco-scalpellum*.

The subgenus *Calantica* Gray is unknown from the Indian and Arabian portions of the Indian Ocean, though occurring abundantly off the South African Coast (Barnard, 1924) and in the Pacific (Broch, 1922, 1931). The number of species of *Scalpellum* hitherto known from the Indian Ocean is seventeen, of which three have hitherto been referred to the subgenus *Smilium* by writers on Indian barnacles, though two really belong to the subgenus *Euscalpellum*.

Of the fourteen species obtained, two, *laccadivicum* and *velutinum* were obtained twice, one, *diota*, three times and the remainder once only. Some stations yielded more than one species, on the South Arabian Coast, one, Sta. 54, *Sc. elegans* and *Sc. woodmasoni*, and in the Zanzibar Area no less than four, namely : Sta. 108, *Sc. laccadivicum* and *Sc. minutum*, Sta. 115, *Sc. diota* and *Sc. velutinum*, Sta. 118, *Sc. diota* and *Sc. formosum*, Sta. 122, *Sc. diota*, *Sc. lambda* and *Sc. longius*.

Subgenus Smilium Gray.

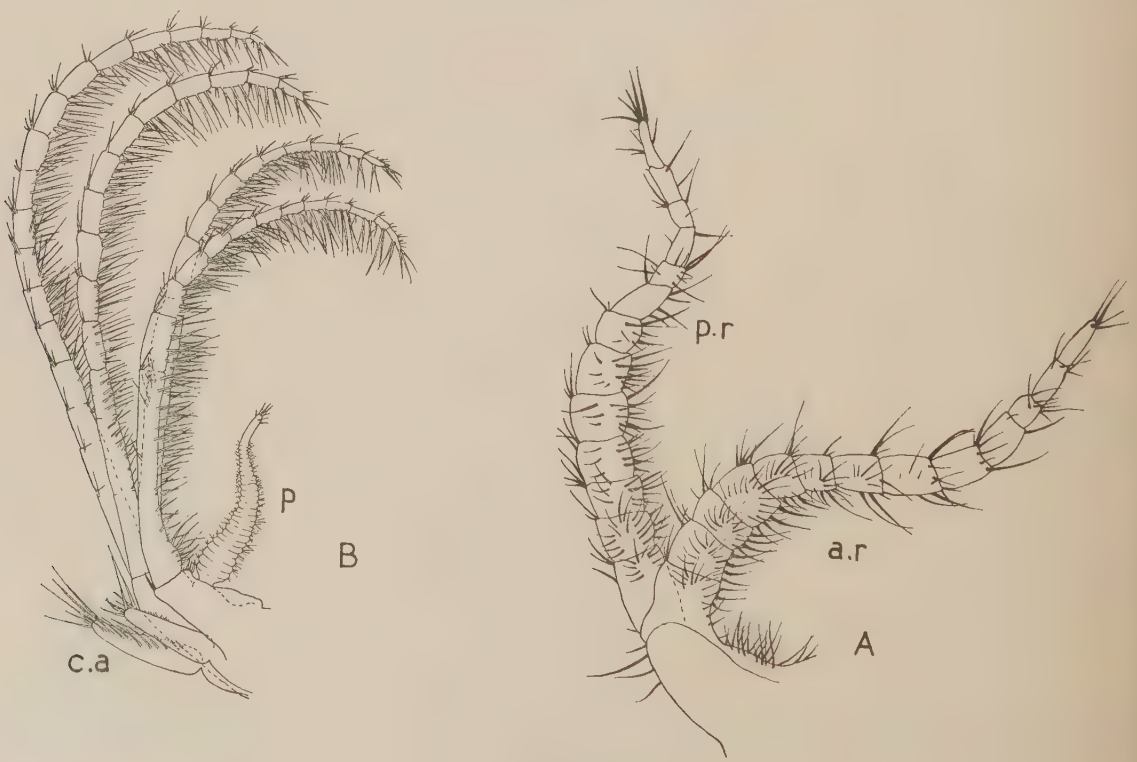
This subgenus is represented by a single species only :

Scalpellum (*Smilium*) *kampeni* Annandale.

Scalpellum (*Smilium*) *kampeni*, Annandale, 1909*b*, p. 267, text-figs. 1–4 ; 1910*c*, p. 82.

Occurrence.—Sta. 24, Gulf of Aden, depth 73–220 metres ; 2 specimens attached to a branched Hydroid, also encrusted with a sponge, *Balani* and various tubicolous Polychæts.

Remarks.—The larger specimen is of a creamy-white colour tinged with orange-pink in the region of the tergum, carina and latera, owing to the colour of the underlying membrane. The membrane appears to be white under the scutum. The external



Text-Fig. 5.

chitinous membrane is pale yellow, and bears fine hairs in irregular patches on the capitulum and peduncle. These hairs were apparently absent on the specimens from Further India and the Malay Archipelago, as they are not mentioned by Annandale.

In the shape of the different valves both specimens agree closely with the published descriptions. In the larger specimen the subcarina points directly backwards, and the carinal latera are turned upwards at the tip. In the smaller specimen the reverse is the case, the subcarina being turned up at the tip, and the carinal latera point backwards and are slightly bowed downwards.

The smaller specimen has a deep lemon-yellow capitulum owing to the colour of the underlying membrane. In other respects it falls within the limits of variation recorded by Annandale for the species. As, however, the coloration of these animals is apt to vary to a very great extent, I have no hesitation in placing the specimen in this species. Annandale records that the colour of specimens from Further India varied from deep rose-pink to milky-white ; to which must now be added the possibility of all shades from cream to the deep yellow of the above-mentioned specimen.

The dimensions of the specimens are :

Specimen.	Total length.	Length of capitulum.	Breadth of capitulum.
Larger . . .	17·0 mm.	9·5 mm.	6·0 mm.
Smaller . . .	10·0 ,,	6·0 ,,	4·0 ,,

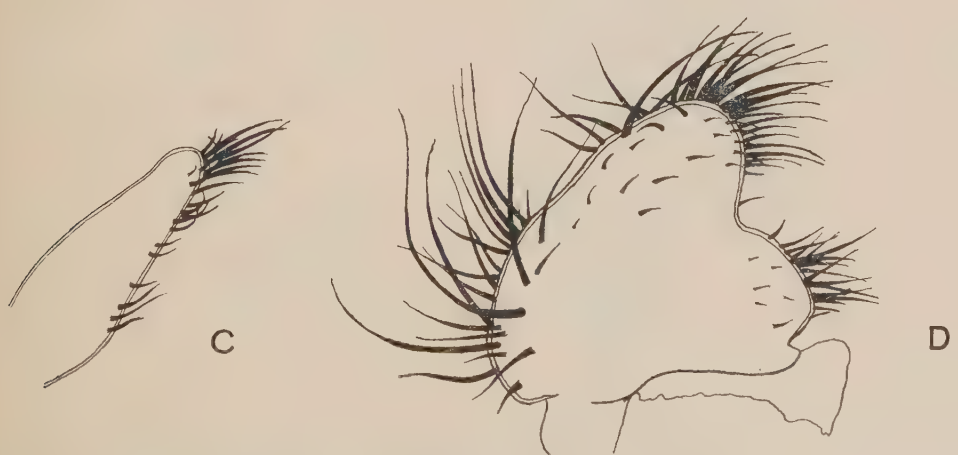
Subgenus Euscalpellum Hoek.

This subgenus is represented by two species only.

Scalpellum (*Euscalpellum*) *bengalense* Annandale. (Figs. 5, 6.)

Scalpellum (*Smilium*) *bengalense*, Annandale, 1906, p. 395 ; 1908, pl. i, fig. 5 ; 1916, p. 129, pl. vi, figs. 3, 4, pl. vii, fig. 3, pl. viii, figs. 1–5.
Scalpellum (*Smilium*) *bengalense*, Stewart, 1911, p. 44, pl. vi, figs. 7, 10.
Scalpellum (*Smilium*) *bengalense*, Calman, 1918, p. 102, text-fig. 1.

Occurrence.—Sta. 89, Northern Area of the Arabian Sea, depth 193 metres ; 15 specimens, both large and small, attached to a Gorgonian, probably *Gorgonella umbraculum* Ellis and Solander.



Text-fig. 5.—Appendages of *Sc.* (*Euscalpellum*) *bengalense* Annandale. A, Cirrus I, × 19. B, Cirri VI and caudal appendages. C, Palpus, × 48. D, Maxilla, × 48. *a.r.*, *p.r.*, anterior and posterior rami of cirrus I. *c.a.*, caudal appendages. *p.*, penis.

Description.—The internal anatomy of the species has been described to some extent by Annandale, but no figures have appeared of certain of the mouth appendages.

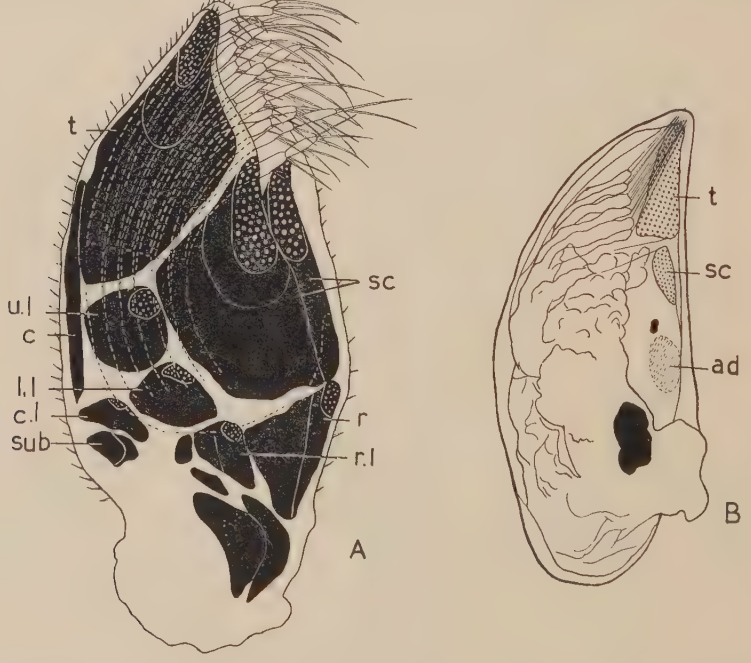
The palpus (Fig. 5 c) is conical, and bears very short setæ on the inner edge only and a tuft of rather longer and stouter setæ at the distal extremity.

The second maxilla (Fig. 5 d) is a lobe-like structure divided into three regions by slight notches in the margin. The upper and inner areas are separated by a much deeper notch than that separating the upper and outer lobes. All these lobes bear setæ; those on the outer lobe are very long and almost hair-like, some being as much as half the length of the appendage. The surface of the appendage bears a few scattered, fine, short setæ.

The cirri agree in structure with Annandale's brief diagnosis. As no figures of these have been published hitherto, I give figures of the first cirrus and also of the sixth pair together with the caudal appendages and penis. In the specimen figured the penis is rather more annulated than in the one figured by Annandale. The caudal appendages also appear to be somewhat shorter, falling short of the junction of the rami of the sixth cirrus, whereas Annandale remarks that they reach rather beyond this point.

Remarks.—The specimens agree closely with Annandale's description of the species. Several specimens were opened and all possess three ovigerous lamellæ, the middle one shorter than the other two as described and figured by Calman (1918).

Sewell (1926) has shown for *Lithotrya nicobarica* that the proportional length of the caudal appendages, in relation to the sixth cirri, decreases with the increase in size of the animal. The specimen of *Sc. bengalense* examined is smaller than that described by Annandale. Hence, if a similar condition exists in this species, it would be expected that the caudal appendages would be larger in proportion. As mentioned above, this is not so. It must not be assumed, however, that a similar type of relative growth does



Text-fig. 6.—*Sc.* (*Euscalpellum*) *bengalense* Annandale. A, Young hermaphrodite, × 48. B, Late cypris larva with developing plates, × 48. *ad.* adductor muscle. *c.*, carina. *c.l.*, carinal latus. *l.l.*, infra-median latus. *r.*, rostrum. *r.l.*, rostral latus. *sc.*, scuta. *sub.*, subcarina. *t.*, tergum. *u.l.*, upper latus.

not occur in *Sc. bengalense*, as there is great variation in the relative length of the appendages, and insufficient specimens have been examined to enable a satisfactory conclusion to be reached.

Several individuals were opened in search of complemental males. None were found, however, but two attached pupæ were found on one individual. On the occludent edge of the scutum of a second was found a young hermaphrodite with all its capitular valves developed and the scutum and tergum showing each one growth-ring (Fig. 6 A). Near this individual was attached a pupa in process of metamorphosis into the adult (Fig. 6 B). There is a distinct skin within the cypris shell, and the rudiments of scutum and tergum can be made out. The adductor muscle also is distinguishable. The peduncle has not yet straightened out, but is at right-angles to the capitular region. The nauplius eye is still present and there is no sign of the mouth-parts, the region immediately in front of the cirri being entirely undifferentiated.

Almost all the published descriptions of *Scalpellum bengalense* Annandale have appeared under the title *Smilium bengalense*. There is, however, no doubt that this species belongs to the *Euscalpellum* section of the genus, as is mentioned by Pilsbry (1908).

Scalpellum (*Euscalpellum*) *rostratum* Darwin. (Fig. 7.)

Scalpellum rostratum, Darwin, 1851, p. 259, pl. ii, fig. 7.
Scalpellum (*Euscalpellum*) *rostratum*, Hoek, 1907, p. 65, pl. v, fig. 13.

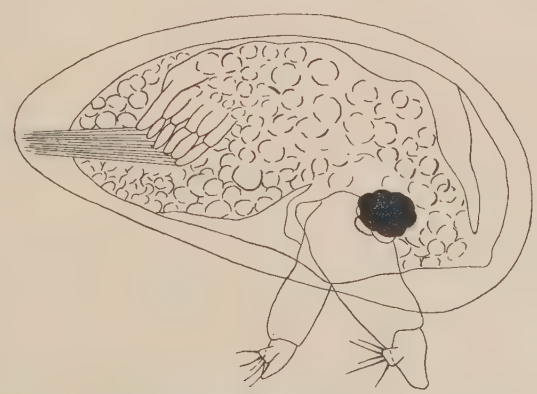
Occurrence.—Sta. 43, South Arabian Coast, depth 83–100 metres; 2 specimens attached to what appear to be fragments of chitinous Polychæt tubes.

Remarks.—The specimens agree very closely with the excellent description given by Darwin in his monograph. The peduncle, however, is rather larger than in Darwin's specimen, where it was about half the capitular length. In the present specimens the lengths are :

	I.	II.
Capitulum . . .	7·5 mm.	7·0 mm.
Peduncle . . .	5·5 ,,	5·0 ,,

Thus the peduncle in these specimens is about three-fourths the length of the capitulum.

The larger specimen was opened, but no complemental males were found attached to the integument between the labrum and adductor muscle—the position indicated by Darwin and confirmed by Hoek (1907). In the other specimen, however, two cypris



Text-fig. 7.—*Sc.* (*Euscalpellum*) *rostratum* Darwin. Cypris larva probably of a dwarf male, × *c.* 56.

larvæ were lodged within the opening of the mantle cavity attached to the chitinous membrane between the two scuta, on the occludent or outer side of the adductor muscle.

These two larvæ were stained with carbol fuchsin. Both were young and only recently attached cypris larvæ. No signs of the valves of the adult were to be seen. In one " pupa " the length/height ratio was somewhat less than in the other, and the cirri were shorter and less well developed. These peculiarities are similar to those found by Stewart (1911) for the pupa of *Sc. squamuliferum*. In this species the shorter pupa is said to be that of a male, whereas the longer one is that of an hermaphrodite. As this investigator had a large series of larval forms at his disposal, there seems no reason to doubt that this view is correct. Arguing on similar lines one would suggest that these pupæ are those of an hermaphrodite and a complemental male of *Sc. rostratum*. The supposedly male pupa is figured (Fig. 7), as it does not seem to have been figured previously, Hoek in his report on the Cirripedia only figuring the fully developed complemental male.

Subgenus Scalpellum s. str.

The remaining eleven species of *Scalpellum* all belong to the above subgenus and to the group *Arcoscalpellum* Hoek.

Scalpellum (*Scalpellum*) *abyssicola* Hoek. (Fig. 8.)

Scalpellum abyssicola, Hoek, 1883, p. 114, pl. vi, fig. 12.

Occurrence.—Sta. 185, Gulf of Aden, depth 2000 metres; 2 specimens. (This depth is considerably less than that from which the " Challenger " Expedition obtained the type-specimen, namely 2050 *fathoms*.)

Description.—This species does not seem to have been found since the voyage of the " Challenger " in 1873–76, and owing to lack of material its founder did not describe the internal anatomy of the animal. Accordingly one of the specimens has been sacrificed in order to give a description of the appendages.

The labrum is bullate and the mouth-parts small.

The mandible bears three teeth and an inferior lobe set with a number of short, tooth-like spines. The lowest tooth is slightly curved towards the inferior lobe. At the base of this tooth, and of the inferior lobe, the mandible bears a few very small setæ (Fig. 8 d).

The first maxilla (Fig. 8 e) bears eight stout spines on its biting edge, the two uppermost being very long.

The second maxilla (Fig 8 f) has slender setæ disposed in three clusters on its margin and a few short stout setæ on its surface. There is nothing peculiar in its shape.

The cirri, except for the first pair, are long and slender with cylindrical, elongated segments. The first pair are somewhat removed from the others, and have seven segments in the anterior rami and ten in the posterior. The segments, except the first in the anterior ramus and the first two in the posterior ramus, are flattened, those of the anterior ramus more so than those of the posterior. A number of setæ on the posterior face of the posterior ramus are exceedingly long, quite twice the length of the segments bearing them.

The caudal appendages are long and five-jointed, and reach just beyond the distal end of the protopodite of the sixth cirrus. They have a distal tuft of three or four long,

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stout setæ and bear one or two long, hair-like setæ at the distal ends of the third and fourth segments.

There is no penis. There are no ovigerous lamellæ.

Remarks.—The specimens agree very closely with the original description and figure, especially when it is remembered that only one specimen was available for description when the species was created.

The carinal margin of the capitulum is only slightly more arched than the occludent margin, less so than is shown in Hoek's figure of the " Challenger " specimen. The tergal

Text-fig. 8.—*Sc.* (*Scalpellum*) *abyssicola* Hoek. A, Adult, × 10. One side of the capitulum removed to show the body of the animal. B, Cirrus I, × 15. C, Bases of cirri VI and caudal appendages, × 15. D, Mandible, × 48. E, Maxilla I, × 96. F, Maxilla II, × 96.

margin of the scutum is almost straight, being very slightly concave in the specimens before me, whereas the " Challenger " figure shows it as being rather markedly concave.

There is a distinct tooth on the carinal margin of the tergum, as is shown in Hoek's figure of the species, and the apex of the tergum is retroverted towards the carina, a fact not mentioned by Hoek though it is implied by his figure.

In his diagnosis of the species Hoek describes the upper latus as hexagonal, whereas his plate definitely shows a pentagonal valve. This is most certainly a textual error, as the present specimens have a pentagonal upper latus. The basal margin of this valve in the present specimens varies slightly from that of the specimen described by Hoek, in which the shorter portion abuts on the infra-median latus. In one of the specimens the basal margin is shared equally by the infra-median latus and the rostral latus. In

the others and larger specimen the rostral latus almost excludes the infra-median latus from the margin of the upper latus. These small variations, however, are of no specific value, as the variation is almost as great on the two sides of the same individual.

These two specimens are both smaller than the "Challenger" specimen, having a capitular length of 7·0 mm. and 5·0 mm. respectively as against 8·0 mm. for the type-specimen.

In both specimens search was made for dwarf males, pupæ, or young hermaphrodites, but neither specimen yielded any of these forms. The first specimen opened was in a very imperfect state of preservation and the second but little better, the body being very pulpy, so it may well be that the delicate males or larvæ were destroyed or rendered unrecognizable by the bad state of preservation of the material.

Scalpellum (*Scalpellum*) *diota* Hoek. (Fig. 9.)

Scalpellum diota, Hoek, 1907, p. 87, pl. vii, figs. 15, 15*a*.

Occurrence.—(i) Sta. 115, Zanzibar Area, depth 690 metres; numerous very small specimens, apparently referable to this species, attached to a Gasteropod shell housing a hermit crab.

(ii) Sta. 118, Zanzibar Area, depth 1792 metres; 2 large specimens.

(iii) Sta. 122, Zanzibar Area, depth 732 metres; 2 large specimens.

Description.—This species, like the preceding, was described by Hoek from a single specimen and the soft parts of the animal were not investigated. I have been unable to find any reference to the structure of the animal in subsequent literature on the genus, and so give a brief description of the animal and its appendages.

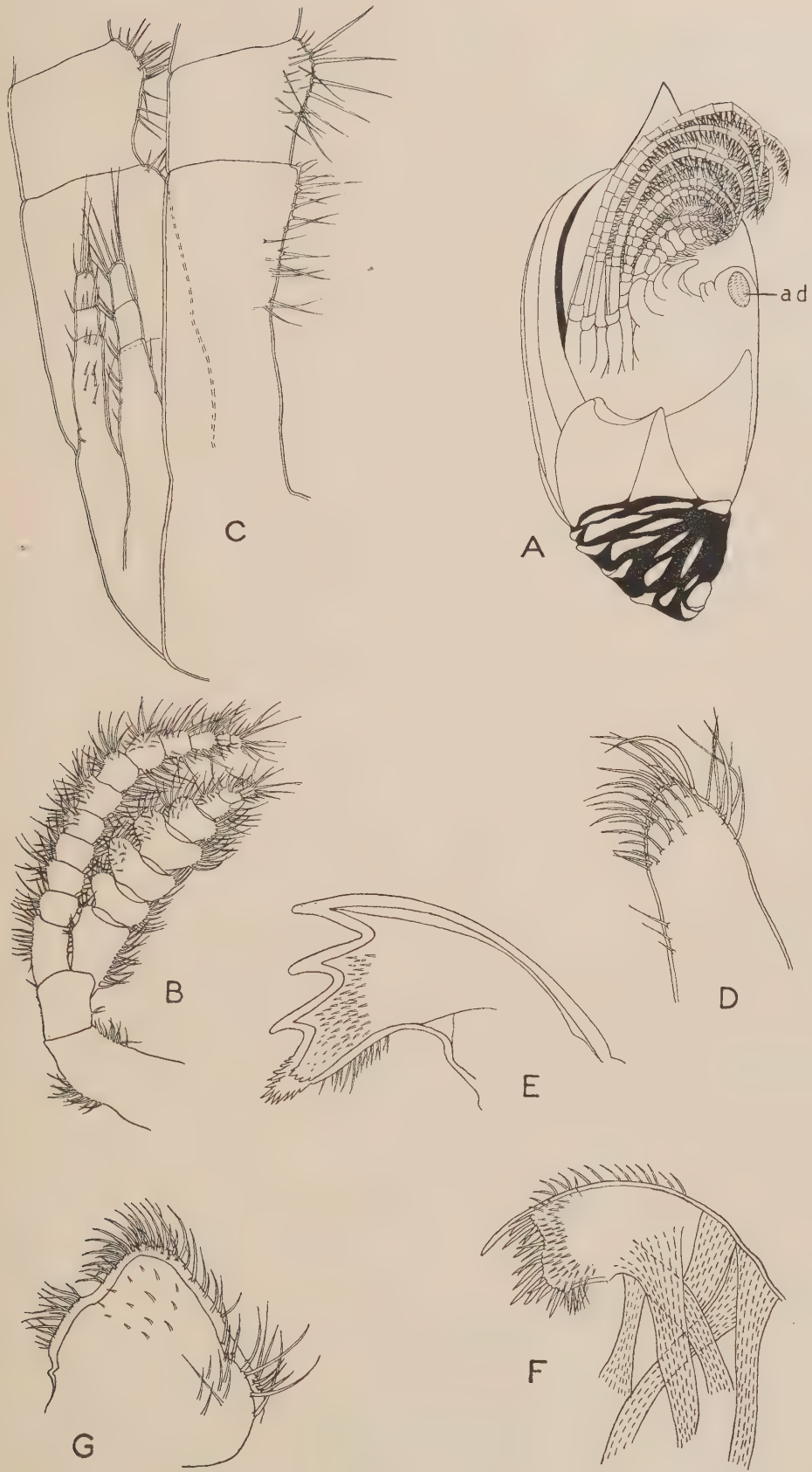
The animal, in spirit, is of a brownish tinge with traces of purple on the cirri and mouth-parts, particularly on the first two pairs of cirri. The colour in life was probably purplish, as in many of the pedunculate barnacles.

The labrum is conical and directed forwards, lying almost parallel to the body and at right angles to the long axis of the capitulum. The palpus is conical with a large crown of setæ. The mandible is three-toothed with a pectinated inferior lobe. There are short setæ on the sides of the appendage and eight or nine pairs of rather long setæ along the ventral border.

The first maxilla has a single large upper spine. The distal border of the appendage is slightly notched. The portion of the margin below the notch bears three or four spines rather larger than the remainder but inferior in size to the large upper spine. The lower portion bears nine or ten spines in all, of varying stoutness. The notch and upper portion together bear seven or eight spines below the large upper spine. The convex or outer margin bears a few slender setæ, and there is a small cluster on the very short inner margin.

The second maxilla is of the usual type, the setæ being collected into three groups. The apical group spreads in a linear manner along the outer edge of the appendage. The outer group of setæ extends on to the posterior aspect of the maxilla, and those setæ nearest the apex of the appendage overlap the lowermost setæ of the apical group. There are also a few short setæ on the posterior surface of the appendage in its distal portion.

The first cirrus is far removed from the second and is situated at a much higher level, its base being nearly level with the distal end of the first joint of the second cirrus. The first joint of its protopodite is stout and twice as long as broad. The second is as broad as long. The anterior ramus is eight-segmented and greatly flattened. The second to fifth segments have large wing-like expansions, the third and fourth being considerably



TEXT-FIG. 9.—*Scalpellum diota* Hoek. A, Complete animal with one side of capitulum removed, × 4. B, Cirrus I. C, Cirri VI and caudal appendages, × *c.* 15. D, Palpus, × 32. E, Mandible, × 20. F, Maxilla I, × 20. G, Maxilla II, × 20. *ad.*, adductor muscle.

larger than the rest. The two distal segments are very small. The posterior ramus is twelve-segmented and very nearly cylindrical. The two terminal segments are likewise very small. The first segment is approximately twice as long as broad, and the others more or less as broad as long. Both rami of cirrus I bear dense tufts of setæ on the anterior and posterior faces of the segments. There is a third dense row of setæ on the inner face of each ramus, and a few of the middle segments of both rami bear short setæ on the posterior part of the outer face.

The remaining cirri, II–VI, are uniform and have cylindrical segments about twice as long as broad, except for the elongated first segment and a few short ones following it.

The caudal appendages are short and three-segmented, reaching only about three-fourths of the way up the first segment of the protopodite of the sixth cirrus. They bear a terminal tuft of setæ reaching to the joint between segments 1 and 2 of the cirrus. The appendages bear setæ at the junction of the segments and also on the body of the first segment.

There are no ovigerous lamellæ.

Remarks.—All the specimens are white, and are devoid of the red spots mentioned by Hoek as occurring on his single specimen from the Malay Archipelago. It is highly probable that this colour is a variable character, as is the case in *Sc. rubrum*, where green and white forms have been obtained, as well as specimens exhibiting the typical red colour of the type-specimen. This is rendered more probable as, on their general form, *Sc. rubrum* and *Sc. diota* are nearly related, as is pointed out by Hoek.

Apart from this variation in colour the present specimens agree in the main with the description of the type-specimen, the only slight variation being in the infra-median latus, a valve that seems especially liable to small variations in shape. The valve broadens towards the base rather more than in the type. In some of the young specimens from station 115, however, the infra-median latus more nearly resembles that of the type. In one of the adult specimens the valve is reduced and almost conical with the upper end pointed, and is more like that figured in the " Siboga " report : it has, however, a round protuberant portion projecting from the surface of the capitulum and is almost certainly malformed. The small specimens show all gradations between the slightly expanded valve of the type-specimen and the more strongly expanded valve of the large specimens obtained by the expedition. It would thus seem that this valve has a somewhat variable shape and becomes broader with increasing age.

In two of the large specimens there is a sixth longitudinal row of peduncular plates, that, however, consists of only three or four scales.

Scalpellum (*Scalpellum*) *elegans* Hoek.

Scalpellum elegans, Hoek, 1907, p. 107, pl. viii, fig. 9.

Occurrence.—Sta. 54, South Arabian Coast, depth 952 metres ; 1 entire but broken specimen.

Remarks.—The depth is about half that (1886 metres) at which the type-specimen was found. Accompanying it in the same haul were six specimens of *Sc. wood-masoni* Annandale.

The specimen agrees fairly closely with Hoek's original description of the species.

The length of the animal is 26·5 mm., of which the capitulum occupies 18·0 mm. It is thus slightly larger than the type-specimen.

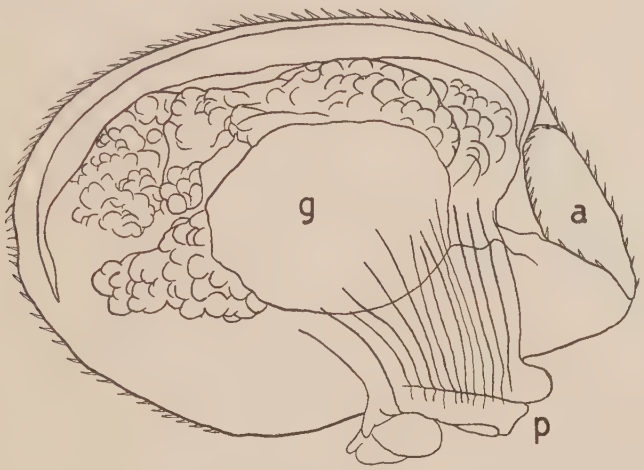
The appendages of this species were not described by Hoek, doubtless because only a single specimen was available, and the species does not seem to have been found subsequently. The specimen has not been dissected, as this would have entailed the complete destruction of an already badly damaged example.

Scalpellum (*Scalpellum*) *elongatum* Hoek. (Fig. 10.)

Scalpellum elongatum, Hoek, 1907, p. 93, pl. iv, figs. 8, 9.
Scalpellum elongatum, Nilsson-Cantell, 1928, p. 8, text-fig. 4; 1932, p. 3, text-fig. 1.

Occurrence.—Sta. 159, Maldive Area, depth 923–1662 metres; 1 specimen attached to a single valve of a dead lamellibranch, probably *Verticordia* (= *Euciroa*) *eburnea*.

Remarks.—This specimen is referred to this species, though with some hesitation, as it shows several variations from the published descriptions.



Text-fig. 10.—*Sc.* (*Scalpellum*) *elongatum* Hoek; complemental male, × 64. *a.*, aperture of mantle. *g.*, testis. *p.*, peduncle.

The general shape of the capitulum agrees with that of the type. The infra-median latus is very small and lies over the inner basal angle of the carino-lateral plate. In this it agrees with the figure of a specimen in the collection of the British Museum, published by Nilsson-Cantell (1928, Text-fig. 4).

The shape of the tergum is rather different from that in previously described specimens. The carinal angle is produced somewhat between the carina and upper latus, thus increasing the length of the carinal and scutal margins; at the same time the scutal portion of the latter margin is concave and receives the convex tergal margin of the scutum.

The peduncular scales are small, closely set, and embedded in chitin so as to be somewhat indistinct. In this they differ somewhat from any of the published figures which show these scales as fairly distinct.

As this species seems to be very variable in appearance I have referred the present specimen to it rather than risk creating a new species for its reception, a procedure, in the opinion of the writer, to be avoided if possible in a genus as variable and imperfectly known as *Scalpellum*.

Two complemental males were attached to this specimen, just within the mantle cavity in fossettes, 1 to 2 mm from the occludent margin of the scutum about the middle of the margin. Both were situated on the left side of the animal. The dwarf male is devoid of plates, oval, and sac-like. The peduncle is short and distinguishable on account

of its longitudinal muscle-fibres. The testis is a large spherical body lying in the centre of the animal. The opening of the mantle is oval, or round, and small. The mantle is covered externally with short, simple setæ.

Scalpellum (*Scalpellum*) *formosum* Hoek.

Scalpellum formosum, Hoek, 1907, p. 110, pl. viii, figs. 11, 11*a*.
Scalpellum formosum, Nilsson-Cantell, 1921, p. 187, text-fig. 27.

Occurrence.—Sta. 118, Zanzibar Area, depth 1792 metres; 1 specimen in the same haul as two of the larger specimens of *Sc. diota*.

Remarks.—It closely resembles the description of the type-specimen. The rostrum is very narrow and is almost covered by the rostral latera, as in one of the two " Siboga " specimens.

No dwarf males or developmental stages were found attached to the specimen.

Scalpellum (*Scalpellum*) *laccadivicum* Annandale.

Scalpellum laccadivicum, Annandale, 1906, p. 393; 1908, pl. i, figs. 3, 4.
Scalpellum polymorphum, Hoek, 1907, p. 86, pl. vii, figs. 9–11.

Occurrence.—(i) Sta. 107, Zanzibar Area, depth 439 metres; 2 specimens.

(ii) Sta. 108, Zanzibar Area, depth 802 metres; 1 specimen attached to a piece of dead *Lophohelia*-like coral, covered with a dense growth of sponges and other epizoic organisms.

Remarks.—All the specimens resemble the complete form (form A) of *Sc. polymorphum* Hoek more closely than the typical *Sc. laccadivicum* of Annandale. However, the specimens have many points in common with both forms, and it seems advisable to include them all under one species, as is done by Annandale.

As regards depth, the specimens come well within the previously recorded range of the species. According to Annandale (1913) the shallowest known habitat was that recorded by the " Siboga " off the Kei Islands and Sumbawa (397 metres). At the other extreme we have specimens obtained by the R.I.M.S. " Investigator " in the Laccadive Sea at a depth of 1154 fathoms (2130 metres).

Scalpellum (*Scalpellum*) *lambda* Annandale.

Scalpellum lambda, Annandale, 1910*a*, p. 115; 1916, p. 127, pls. vii, viii.

Occurrence.—Sta. 122, Zanzibar Area, depth 762 metres; 1 specimen.

Remarks.—It agrees very closely with Annandale's description of the type, although an " incomplete " species and hence, perhaps, more liable to variation in the shape of the valves than a " complete " species. The specimen is in no wise intermediate in form between this and *Sc. longius* of the same author. It thus tends to justify Annandale's separation of these two forms as distinct species, though at the time he apparently had some doubts as to the justification of this step, as he remarks (1913, p. 235), " Possibly *Scalpellum longius* as here described is merely a complete form of *S. lambda* . . . ". The validity of these two species is further discussed from the distributional standpoint on p. 60.

The appendages were examined and commented upon in the original description, and as the present collection only contains a single example of the species, I have not dissected it in order to figure those appendages, illustrations of which were not published by Annandale. namely the palpus, second maxilla and first cirrus.

No dwarf males or developmental stages were present except a single egg lying free in the mantle cavity.

Scalpellum (*Scalpellum*) *longius* Annandale. (Fig. 11.)

Scalpellum longius, Annandale, 1913, p. 234 ; 1916, p. 130, pl. vii.

Occurrence.—Sta. 122, Zanzibar Area, depth 762 metres ; 2 specimens.

Description.—The palpus is simply conical, and bears about ten long apical setæ and a few short ones on the surface of the appendage.

The mandible differs somewhat from the description given by Annandale in the shape of the inner angle and in the number of its spines. Annandale says, " . . . the inner angle is produced and forms a projecting portion of relatively large size and with nearly parallel but somewhat irregular edges ; at its extremity it bears two teeth ". In the present specimen the inner angle is no longer than the lowest tooth. Its extremity is rounded and bears six small teeth. The two outer teeth are rather lateral in position

Text-fig. 11.—*Sc.* (*Scalpellum*) *longius* Annandale. A, Cirrus I, × *c.* 33. B, Palpus, × 48. C, Mandible, × 48. D, Maxilla I, × 30. E, Maxilla II, × 30.

and the other four terminal, the two upper curving slightly towards the two lower, which curve in the opposite direction.

The first maxilla bears four spines above the anterior notch ; the three upper are large and subequal, the lowest is much smaller. There are eight to ten smaller spines on the portion below the notch.

The second maxilla is oval with the setæ arranged in only two groups, instead of three as in many species of *Scalpellum*. The inner group is lacking. The apical tuft consists of only a few small slender setæ.

The first cirrus has the rami subequal in length. The anterior ramus is flattened, eight-segmented, and almost straight. The posterior ramus is only slightly flattened, eleven-segmented, and slightly bowed.

The caudal appendages are eight-segmented, the second and third segments being very small. These appendages agree very closely with Annandale's figure of the same structures in *Sc. lambda*.

Remarks.—The specimens agree closely with the description of the type and show no tendency to vary towards *Sc. lambda*.

This species has not been described since the original diagnosis was published in 1913. Only the external appearance of the type has been figured (Annandale, 1916). Accordingly I have here figured the mouth-parts of this species, at the same time mentioning any variations from the type description which occur in the present specimens.

The less well-preserved of the two specimens was dissected. The valves of one side were smashed, but showed a swelling about the region of the upper latus on that side. On opening the capitulum the cause of the swelling was found to be two large females and a male of some species of Bopyrid. The parasites had apparently inhibited the development of the sixth pair of cirri and of one of the fifth pair. All the other appendages and the caudal appendages were fully developed.

Scalpellum (*Scalpellum*) *minutum* Hoek.

Scalpellum minutum, Hoek, 1883, p. 113, pl. v, fig. 12.

Occurrence.—Sta. 108, Zanzibar Area, depth 802 metres ; 1 specimen attached to a piece of dead coral of *Lophohelia* type, encrusted with a felt of sponge.

Remarks.—This exceedingly small species of *Scalpellum* does not seem to have been found since the " Challenger " obtained the type-specimen.

The specimen is 3·5 mm. long and is considerably smaller than the type, which had an overall length of 8·0 mm. In view of the evident youth of the specimen the internal anatomy is not figured here, although no figures of the appendages have hitherto been published.

Scalpellum (*Scalpellum*) *velutinum* Hoek. (Fig. 12.)

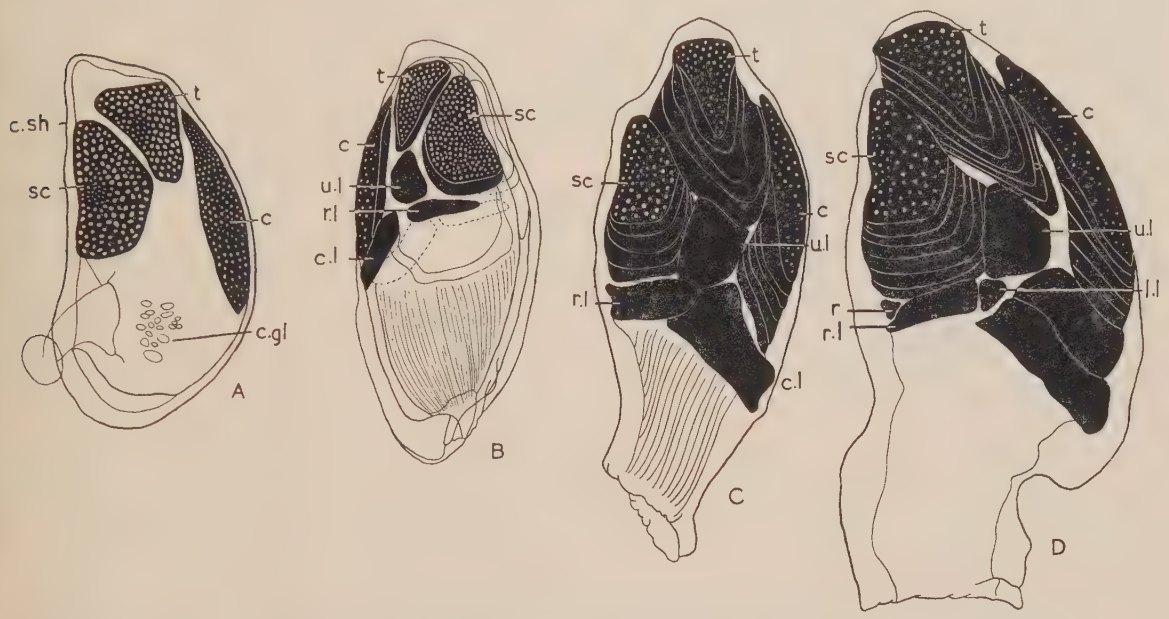
Scalpellum velutinum, Hoek, 1883, p. 96, pls. iv, ix.
Scalpellum velutinum, Gruvel, 1902, pp. 56–63, pl. ii, figs. 3*c*, 10, 14, pl. iii, figs. 27–31, pl. iv, figs. 6, 11–22.
Scalpellum velutinum, Nilsson-Cantell, 1927, p. 743, text-fig. 1 ; 1928, p. 4 ; 1932, p. 1.
Scalpellum eximium, Hoek, 1883, p. 100, pl. iv, figs. 6, 7, pl. x, figs. 10, 10*.

Occurrence.—(i) Sta. 115, Zanzibar Area, depth 690 metres ; 1 large and several young specimens attached to a piece of pumice.

(ii) Sta. 122, Zanzibar Area, depth 762 metres ; 4 large specimens on a piece of coral.

Remarks.—The specimen from Sta. 115 is considerably larger than the others and is practically devoid of hairs : the chitinous membrane is very thin and absent from the apices of some of the valves. The four specimens from Sta. 122 are all of the very hairy type. Numerous newly metamorphosed specimens, apparently of the same species, and several cypris larvæ of varying ages were attached to the large specimen from Sta. 115 and to the piece of pumice.

Several of the specimens contained dwarf males. The position and number of these complemental males seems to vary considerably. As regards their position Hoek (1883) merely remarks " attached to the left-hand scutum "—referring to one of two individuals from a single specimen of *Sc. velutinum*. In the line before he says, " there are not more



Text-fig. 12.—*Sc.* (*Scalpellum*) *velutinum* Hoek. Stages in the development of the adult. A, Late cypris larva. B–D, Young hermaphrodites. *c.*, carina. *c.gl.*, cement gland. *c.l.*, carinal latus. *c.sh.*, cypris shell. *l.l.*, infra-median latus. *r.*, rostrum. *r.l.*, rostral latus. *sc.*, scutum. *t.*, tergum. *u.l.*, upper latus. All × *c.* 16.

than one on each side ". For his species *Sc. eximium*, now regarded as synonymous with *Sc. velutinum*, he merely states that the males are found " at the ordinary place ".

Gruvel gives much more precise data for the position of these individuals. He says (Gruvel, 1902) : " Ces petits êtres se trouvent situés, en grand nombre généralement, dans une duplicature du manteau formant une sorte de fossette placée à la partie interne du scutum. Cette fossette commence à 4 millimètres environ de l'apex de la plaque. Elle s'étend sur une longeur et une profondeur à peu pres égales, en s'arrêtant immédiatement au dessus du muscle adducteur ". This information is certainly sufficiently precise. He then adds that from four to twelve males may be found in this position. In the specimens I examined four males were obtained, one of which is still within its cypris shell, but is definitely a male as it shows the characteristic covering of pectinated setæ. Of these, three were found on one individual. Their position, however, does not altogether agree with that given by Gruvel, as they were attached between the two scuta in the depression formed between them and the adductor muscle. Evidently therefore the

position of the complemental males can vary to some extent, though they do not migrate very far into the mantle cavity itself.

The structure of the dwarf males agrees very closely with the figures published by Gruvel (1902) in his report on the " Talisman " cirripedes.

A number of very young hermaphrodites were obtained from the large specimen, some attached to the peduncle or substratum, and others from just within the mantle cavity on the scutal edge near the position occupied by the dwarf males when present. I have figured several of the youngest in order to show the development of the capitular valves. The youngest specimen (Fig. 12 A) is still enclosed in the cypris shell and has not yet straightened out. The umbones of the tergum, scutum and carina are present and are of considerable size, covering over half the capitular portion of the animal. There are as yet no traces of the upper latus or of the lower whorl of valves.

The next specimen figured shows slight additions to the upper whorl of valves, and the upper latus and two of the lower whorl of latera, the carinal latus and what, from its shape, should be the rostral latus, have made their appearance. The latter valve, however, lies half under the upper latus and does not reach to the occludent margin. There is as yet no trace of a third valve in the lower whorl. The peduncle has straightened out and the attaching antennæ are distinctly visible. There are, however, no peduncular scales as yet.

In the third specimen figured (Fig 12 C), the animal begins to take on the adult shape. The valves have considerably increased in size. The scutum and tergum show four growth-rings and the carina five. The upper latus, carinal and rostral latera also have increased in size. The two last-named overlap slightly, and there is still no trace of an infra-median latus. All the valves are now in contact over a considerable portion of their periphery. The peduncle is slightly constricted off from the capitulum and has a definite flat base of attachment. The antennæ are no longer visible.

At a still later stage the first peduncular scales appear on the carinal side just below the carinal latera. These scales appear to develop before the infra-median latera, as specimens occur in which they are present and the infra-median latera are absent, and also slightly larger specimens in which both are present. Fig. 12 D shows an individual with all the capitular valves and the first peduncular scales. The rostrum seems to appear between the development of the first peduncular scales and the infra-median latus.

The majority of the peduncular scales seem to vary in time of origin. Some specimens show distinct white transverse markings on the peduncle, denoting the position of the developing scales, even before the infra median latera have developed. On the other hand they may still be absent in specimens with a complete set of capitular plates.

Scalpellum (*Scalpellum*) *wood-masoni* Annandale.

Scalpellum wood-masoni, Annandale, 1906, p. 396 ; 1908, pl. i, fig. 1.
Scalpellum wood-masoni, Nilsson-Cantell, 1932, p. 3, text-fig. 2.

Occurrence.—Sta. 54, South Arabian Coast, depth 952 metres ; 3 specimens associated with *Sc. elegans* on a tubular branching sponge.

Remarks.—These specimens agree reasonably closely with the descrip ion of the type. The carina is somewhat more concave than is implied by Annandale's description.

His expression is " dorsal surface flat or feebly concave ". The dorsal surface is very definitely concave in all the specimens collected from this area. Annandale adds that the dorsal surface of the carina is " without definite borders ". In the present specimens the three regarded as most typical are variable as to this character. One may be regarded as having the dorsal surface of the scutum bounded by ridges formed by the concave nature of the dorsal surface itself. In the other two specimens the carina is definitely possessed of borders. The other valves agree with the diagnosis of the species.

Scalpellum (*Scalpellum*) *wood-másoni* var. *murrayi* var. nov. (Fig. 13.)

Occurrence.—Sta. 54, South Arabian Coast, depth 952 metres ; 3 specimens.

Remarks.—These specimens differ in several characters from the typical form. The capitulum is covered by a very much paler chitinous membrane. The occludent margin is not straight, but both scutum and tergum have curved occludent margins, the two curves intersecting where the apex of the scutum overlaps the tergum. The apex of the tergum has a tendency to be slightly retroverted towards the carina. This is most marked in the specimen with the least straight occludent margin. The most striking difference, however, is in the infra-median latus. This plate is horn-shaped and slightly retroverted towards the occludent margin of the capitulum in the typical form. In these specimens, however, the umbo is median and the valve is hourglass-shaped and slightly turned, in the upper part, towards the carinal margin of the capitulum. In the

Text-fig. 13.—*Sc.* (*Scalpellum*) *wood-masoni* Annandale var. *murrayi*. Specimen showing the hourglass-shaped infra-median latus.

smallest specimen, however, the upper part of the hourglass-shaped valve is only feebly developed.

No dwarf males were present on either the typical form or the variety.

Suborder VERRUCOMORPHA Pilsbry 1916.

Genus VERRUCA Schumacher.

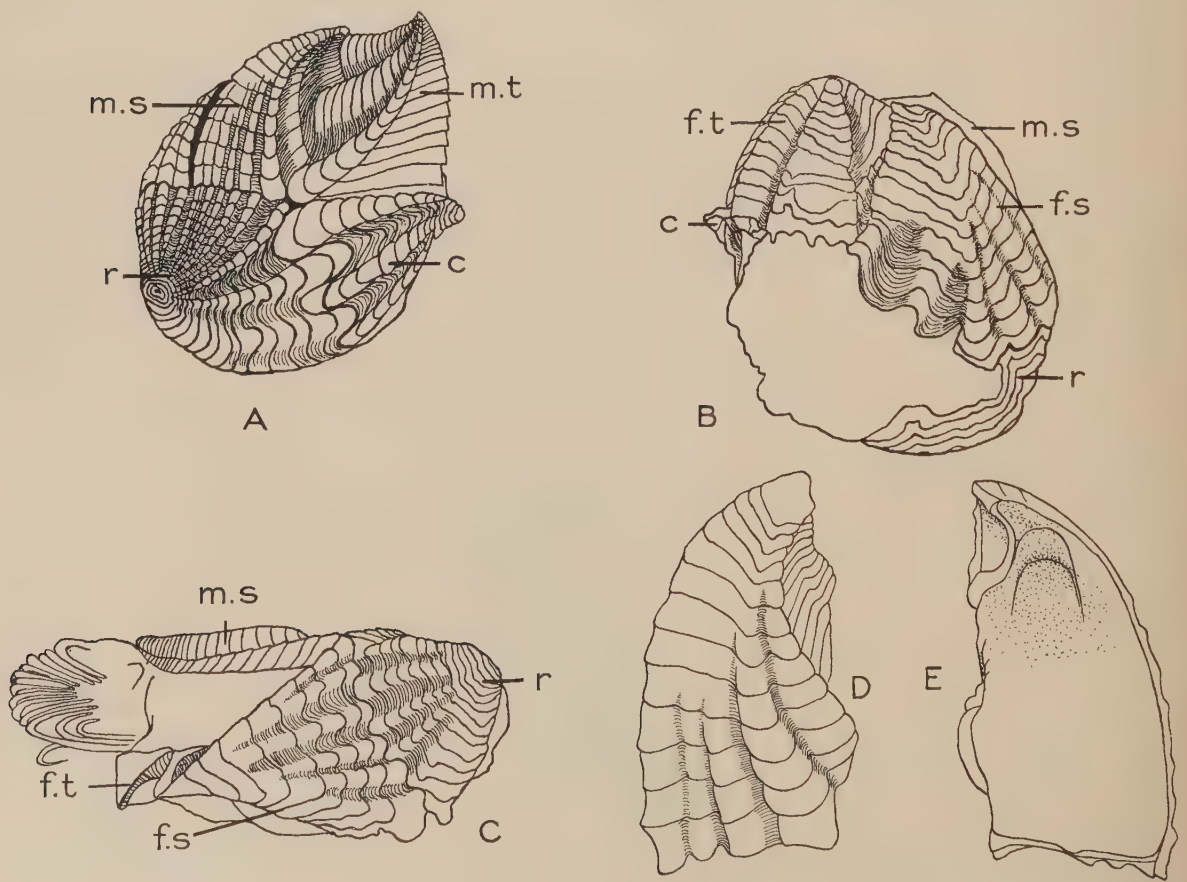
Representatives of this genus were collected at four stations in the Arabian Sea, four species being collected in all, and of these three must be considered as new to science and are described below. Two, *V. murrayi* sp. nov. and *V. sewelli* sp. nov., were the only species to be obtained at more than one station and both belong to the subgenus *Rostrato-verruca* Broch ; the third, *V. macani* sp. nov., belongs to the subgenus *Verruca* (s. str.) of Pilsbry.

Verruca (*Rostrato-verruca*) *murrayi* sp. nov. (Fig. 14.)

Occurrence.—(i) Sta. 105, Zanzibar Area, depth 310 metres ; 1 specimen.

(ii) Sta. 110, Zanzibar Area, depth 333 metres ; 8 specimens.

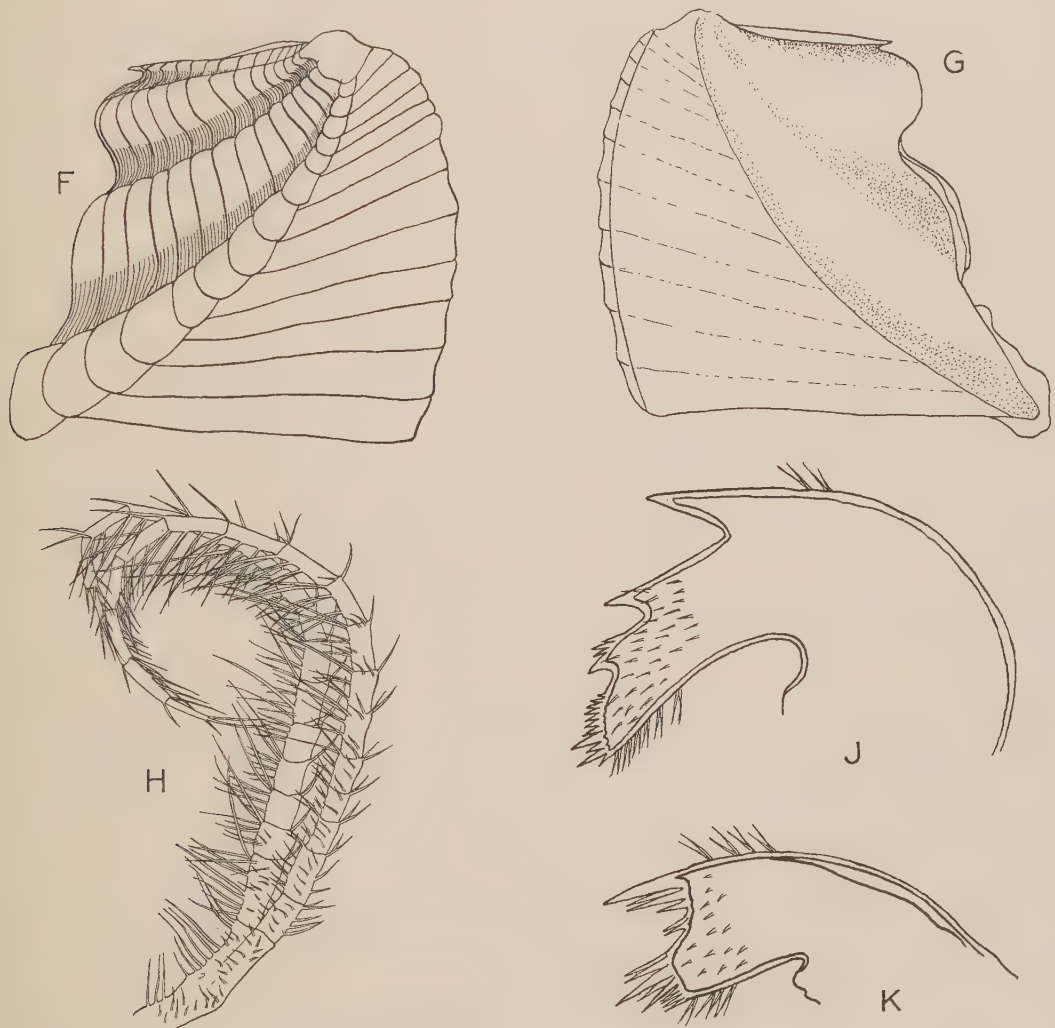
Diagnosis.—Basis rounded ; rostro-carinal wall strongly convex dorsoventrally, the upper part parallel to the plane of the basis ; rostrum patelliform, larger than carina, nearly twice as large when viewed from above (Fig. 14 A), with the umbo much removed from the scutal border, sub-central ; articular edges of rostrum and carina forming an angle of about 170° ; umbo of carina produced ; scuto-tergal wall very oblique ; basal



Text-fig. 14.

edge of wall not inflected ; movable operculum more or less parallel to basis ; movable scutum and tergum with three articular ridges ; carina and rostrum articulating by three strong ribs.

Description.—The movable scutum is small, slightly larger than the ribbed portion of the movable tergum, and approximately triangular. The occludent margin is convex ; the basal margin straight and feebly crenulate owing to the ribs articulating with the rostrum. The apex is pointed and projects slightly over the first ridge of the tergum. Three ridges articulate with the tergum, the first short and separated by a wide furrow from the second. The second is long, running from near the umbo to the articular margin, strongly curved and prominent. The axial ridge is slightly longer than the second and of the same width ; it terminates on the basal margin. Both edges of the ridge are sharply demarcated. Three or four ridges articulate with the rostrum, the first two with definite borders, the other one or two indistinct.



Text-fig. 14.—*Verruca* (*Rostrato-verruca*) *murrayi* sp. nov. A, From side of movable scutum and tergum. B, From side of fixed scutum and tergum. C, Lateral view. All × *c.* 45. D, E, Scutum, external and internal view. F, G, Tergum, external and internal view. H, Cirrus III. J, Mandible, × 96. K, Maxilla I, × 96. *c.*, carina. *f.s.*, *f.t.*, fixed scutum and tergum. *m.s.*, *m.t.*, movable scutum and tergum. *r.*, rostrum. A, B, C are from the type-specimen.

The movable tergum is large and quadrilateral with three articular ridges. The upper margin is formed by the first ridge and is concave. The scutal margin is sinuous; the basal straight and the posterior occludent margin feebly convex. The second ridge is separated from the first by a wide furrow; it is broad with distinct sides. The third or axial ridge extends diagonally across the whole valve and is little more than half as broad as the second. The postaxial portion of the tergum is ornamented by prominent growth-ridges only.

The rostrum has three prominent ridges articulating with the carina, the uppermost very narrow with a deep furrow on either side. The other two have more gently sloping sides and are separated by a shallow furrow. There is a small and irregular, rudimentary, fourth ridge below these. Four small and narrow ridges articulate with the basal border of the movable scutum. The vertical portion or paries of the valve has two broad regular ridges running from the umbo to the basal margin. The rostrum articulates with the fixed scutum by four indistinct narrow ridges.

The carina articulates with the rostrum by three ridges, the two uppermost broad and curving slightly towards the basal margin. The third is narrow and irregular. There are no other ridges on the carina.

The fixed scutum is trapezoid. The basal margin is crenulate and parallel to the occludent. The latter is slightly convex near the umbo, which is bent towards the fixed tergum. The rostral border is crenulate, and articulates with the rostrum by four rather irregular ridges. A small radial area with a very oblique upper margin is present on the tergal side.

The fixed tergum consists of a triangular parietal area with very irregular growth-lines. On the scutal side a triangular alar area meets the radius of the scutum. A larger radial area on the carinal side articulates with the carina. Both ala and radius are ornamented with growth-ridges only.

The mandible has three sharply acute teeth and a large inferior angle with nine small teeth. There are three minute teeth on the upper edge of the third tooth.

The first maxilla has the upper part of the anterior margin cut away. There is one large upper spine with a pair of shorter ones below, followed by three short ones; these spines are widely spaced. There is a spineless gap before the lower teeth, two of which are enlarged.

Cirrus I is somewhat removed from the second. The anterior ramus is about two-thirds as long as the posterior, and consists of eight segments, as broad as they are long. The posterior ramus consists of eleven segments all longer than they are broad, the lowest about one-and-a-half times as long, increasing to three or four times as long as broad at the tip.

Cirrus II is removed slightly from the third, and the anterior ramus is about three-fourths the length of the posterior. The number of segments is nine and thirteen in the anterior and posterior ramus respectively.

Cirri III–VI have equal rami of from sixteen to eighteen segments. The setæ are very long and hair-like (Fig. 14 H), some of them more than three times as long as the segments bearing them.

Remarks.—This species is characterized by the very oblique scuto-tergal wall, which gives the barnacle the appearance of being pushed over to one side by the comparatively large area of the rostrum between the umbo and the scutum. It is

distinguished from the other species of the subgenus *Rostrato-verruca* by the absence of an inflected edge to the walls (*cp. V. nexa* Darwin), by having only three articular ridges on the movable scutum and tergum (separating it from *V. koehleri* Gruvel, 1907), and by the oblique position of the scuto-tergal wall, which easily distinguishes it from the other three species of this group, namely *V. dens* Broch (1931), *V. intexta* Pilsbry (1912) and *V. krugeri* Broch (1922).

This species is named in honour of Sir John Murray, one of the naturalists on the "Challenger", and later editor of the '"Challenger" Reports', by whose bequest the expedition was made possible and from whom it derived its name.

Verruca (*Rostrato-verruca*) *sewelli* sp. nov. (Figs. 15, 16.)

Occurrence.—(i) Sta. 109, Zanzibar Area, depth 641 metres; 66 specimens, many very small, attached to Echinoderm spines.

(ii) Sta. 111, Zanzibar Area, depth 333 metres; 1 specimen, with *V. capsula* Hoek, on a Gasteropod shell.

Diagnosis.—Shell white with patches of greenish-yellow membrane; walls nearly vertical, the fixed scutum and tergum being only slightly oblique; movable scutum and tergum with three articular ridges; movable scutum triangular, with a very deep adductor pit; movable tergum quadrilateral; rostrum patelliform with ridges extending to all margins except the basal; umbo produced and retroverted towards movable scutum; base of walls more or less inflected in parts; strong myophore pit and ridge on fixed scutum.

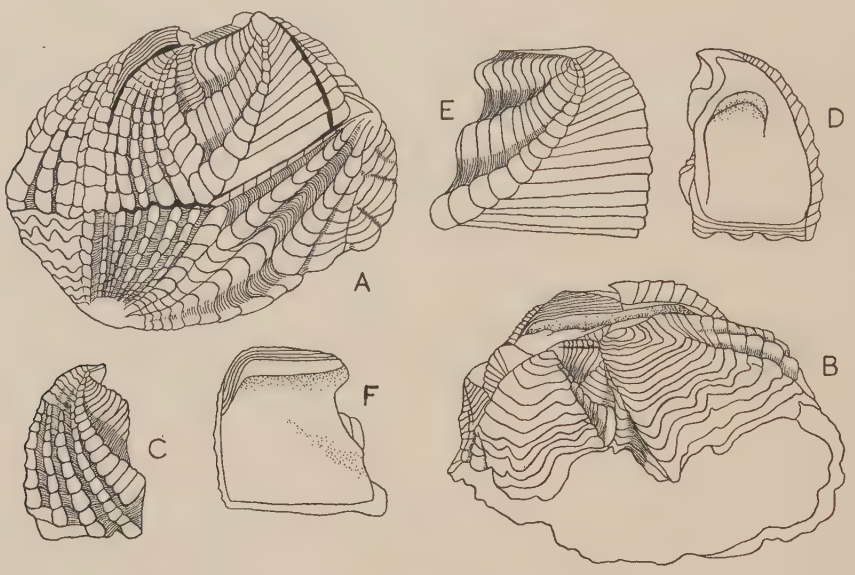
Description.—The movable scutum is triangular, with a crenulate basal margin and strongly curved occludent margin. The tergal margin is sinuous internally owing to the projection of the articular ridges. The apex is slightly inturned. Of the three articular ridges the second is the broadest; the first is comparatively large and only slightly narrower than the second, and the third (axial) ridge is narrow but very prominent. The remainder of the scutum bears three very prominent ridges, separated by deep furrows, and articulating with the rostrum.

The valve is thick with a prominent internal rim along the occludent margin. It is generally concave internally. The adductor pit is situated in the upper half of the valve.

The movable tergum has a straight basal margin, convex posterior occludent margin and slightly concave upper occludent margin. The axial ridge does not project beyond the basal or scutal margins. The apex is bent slightly towards the scutum. The three articular ridges are prominent and sharply marked off by deep furrows; the first ridge is rather narrower than the other two. The posterior half of the valve is ornamented with growth-ridges only. Internally the valve is slightly convex, more so where the valve meets the scutum near the adductor pit so that there is a conspicuous thickening of the tergum. The rostrum has four prominent sharply defined ridges articulating with the corresponding ridges on the movable scutum. Four ridges articulate with the carina, three being rounded and the lowest one flattened. The first and fourth ridges are of equal breadth and about twice as broad as the other two. In a few specimens a fifth ridge is present in this series, and all five ridges may be considerably flatter than in the specimen figured. The paries is ornamented by curved growth-lines only. The basal edge is thickened considerably and projects inwards.

The carina has its upper edge bent at a right angle. The edge abutting on the base

of the tergum makes a straight line with the corresponding scutal edge of the rostrum. The valve is indistinctly divided into two triangular portions. The largest or paries is ornamented by irregular growth-ridges which project from the surface in a number of blunt points. A small ridge, probably the ala, articulates with the fixed tergum. On the rostral side the radial area is large, and commonly bears three distinct ridges articulating with the rostrum. There may be as many as six of these ridges, in which case the lower ones are very small and often indistinctly demarcated, and do not reach far from the margin towards the umbo of the valve, which is situated in the angle of the upper margin. The basal margin is considerably inflected.



Text-fig. 15.—*Verruca sewelli* sp. nov. A, From side of movable valves. B, From side of fixed scutum and tergum. C, D, External and internal view of scutum. E, F, External and internal view of tergum. All × 30.

The fixed scutum consists of a central paries and two radii. The paries has two broad irregular ridges, or rather flutes, formed by the curving of the whole valve. The radial area on the tergal side is small and unornamented except for faint growth-lines. The rostral radial area is as big as the paries and articulates with the rostrum by five prominent ridges. Four of these are subequal in length and breadth. The fifth and lowest is slightly narrower and shorter than the others. The basal margin is not inflected, but slants obliquely inwards to the edge of the ridge forming the lower side of the myophore or muscle attachment. There is a distinct internal longitudinal groove bounded on the side away from the margin by a longitudinal ridge. The groove and ridge together form the articular surfaces joining the fixed scutum to the fixed tergum.

The fixed tergum likewise consists of three triangular portions. The paries is smooth and ornamented by growth lines. There are faint suggestions of vertical ridges. The scutal radius bears two small ridges. It does not reach the occludent margin of the valve, which is formed by the broad flat edge of the parietal portion of the valve. The umbo is removed a little from the occludent margin. The carinal radius is nearly as large as the paries, and bears a prominent marginal ridge running to the end of the occludent margin of the carina.

Internally the fixed tergum has a large V-shaped depression on either side where it articulates with the carina and fixed scutum. There is a horizontal ridge across the middle of the valve. This is the thickest part of the valve, which becomes thinner towards the upper and lower margins.

The palpus is narrow and parallel-sided with setæ on the inner edge and the tip. The terminal setæ are rather longer than the others.

TEXT-FIG. 16.—*Verruca sewelli* sp. nov. A, Mandible, × 48. B, Maxilla I, × 96. C, Maxilla II, × 48. D, Penis and caudal appendages, × 48.

The mandible has three acute teeth and a large lower lobe with six prominent small acute teeth on its anterior face. The extreme basal angle is rounded. There are a few setæ on the ventral margin of the appendage, and others on the surface at the base of the second and third teeth.

The first maxilla has a stout upper spine and a deep notch occupying all the upper half of the biting margin. In the notch are one long thin spine and four progressively shorter spines, the largest of which is only half the length of the long thin one. The lower edge of the notch is bare of spines. The lower portion of the biting edge bears four pairs of enlarged spines and then three pairs of short spines packed very closely

together at the extreme lower angle. A few paired hairs are present on the dorsal and ventral margins of the appendage.

The second maxilla is lobe-like and bears long hair-like setæ in three groups, the outer group being confluent with the terminal.

Cirrus I is situated a little removed from the next. The anterior ramus is three-fourths of the length of the posterior.

Cirrus II is similarly proportioned to cirrus I, but has a much longer protopodite.

Cirrus III has the rami equal, the anterior strongly tapered as in cirri I and II, and the posterior only slightly tapered. The protopodite is almost as long as the rami.

Cirri IV–VI have long equal rami not tapering except at the extreme ends.

The caudal appendages are eleven-segmented, and reach just above the bifurcation of cirrus VI.

The penis is very long and stout in the proximal portion. It is finely annulated throughout its length.

The following table shows the number of segments in the rami of the cirri in one of the specimens examined :

Cirrus.	I.	II.	III.	IV.	V.	VI.
Anterior ramus . . .	12	12	15	19	21	25
Posterior ramus . . .	13	13	15	21	23	26

Remarks.—In the partially inflected edge to the walls this species is allied to *V. nexa* Darwin, and particularly to the variety *V. nexa alba* Pilsbry (1907*b*). It differs from this subspecies in not having the apices of the fixed scutum and tergum produced into beaks, in the greater number of articular ridges uniting the rostrum and carina, and in the incomplete development of the inflected basal edges of the walls.

This species is named in honour of Lt.-Col. R. B. Seymour Sewell, sometime Director of the Zoological Survey of India and Leader of the " John Murray " Expedition.

Verruca (*Metaverruca*) *capsula* Hoek.

Verruca capsula, Hoek, 1913, p. 130, pl. xii, figs. 1–3, pl. xiii, figs. 1–4.

Occurrence.—Sta. 110, Zanzibar Area, depth 333 metres ; 3 specimens growing on a Gasteropod shell.

Remarks.—In the form and ornamentation of the walls the specimens agree very well with the description of the type. The growth-ridges are much reduced, almost to lines alone, and consequently the walls are very nearly smooth. The growth-lines are somewhat more regular than in the figure of the type. The articular folds, or flattened ridges, of the rostrum and carina vary slightly in size and number. There are five on each valve, of which two are large in two of the specimens, and three in the third specimen.

The movable tergum differs from that of the type in that there is no deep excavation in its scutal margin. Instead there are two shallow indentations almost confluent, and corresponding to two small projections on the tergal wall of the movable scutum. There is thus no large protuberance on the tergal wall of this valve. The rim on the two occludent margins of the tergum is very small and scarcely perceptible.

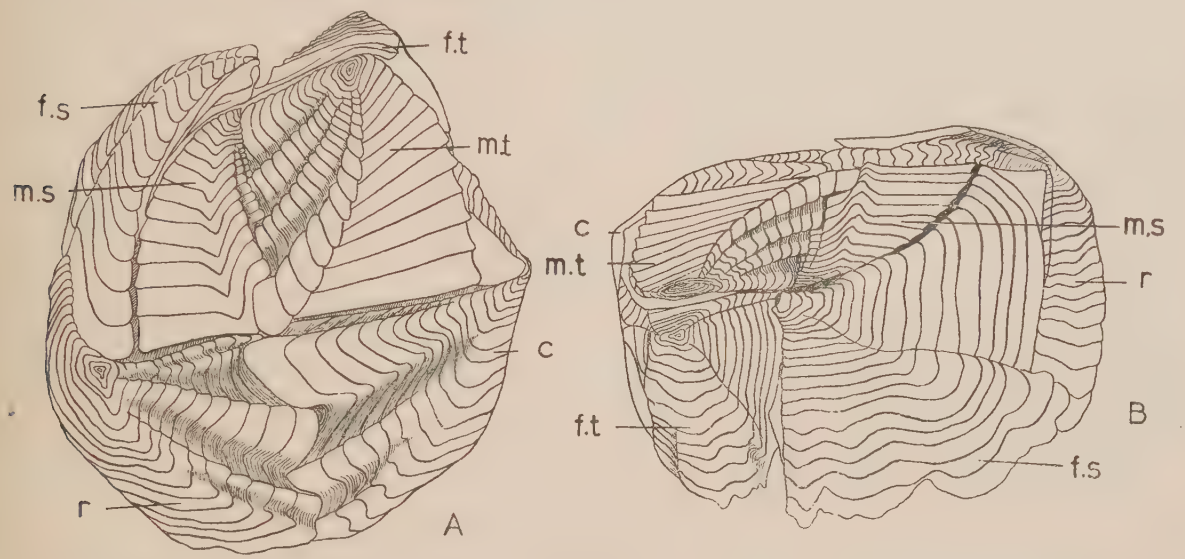
One of the three specimens shows slight indications of ridges on the post-axial part of the scutum. They are not very distinct, however, and the specimen agrees in other characters with the other two, so it is included under this species.

Verruca (*Verruca*) *macani* sp. nov. (Fig. 17.)

Occurrence.—Sta. 122, Zanzibar Area, depth 762 metres; 1 specimen, slightly damaged.

Diagnosis.—Shell white, with thin membrane adhering in grooves; basis circular; walls nearly vertical; plane of operculum parallel to basis; movable scutum and tergum with four articular ridges; remainder of these valves with growth lines only; umbo of rostrum marginal; rostrum and carina articulating by three flattened ridges; suture between fixed tergum and fixed scutum vertical, nearly straight.

Description.—The movable scutum is triangular. The opercular side is strongly convex, the articular straight except for a projection at the end of the third articular ridge. The basal margin is straight. The first articular ridge is minute, and almost



Text-fig. 17.—*Verruca macani* sp. nov. A, From side of movable valves. B, From side of fixed scutum and tergum. Lettering as in Text-fig. 14. Both figures from the type-specimen.

obscured by the small, narrow second; the third is much larger and has the upper edge sharply demarcated. The lower edge curves into the furrow between ridges 3 and 4. The fourth (axial) ridge has straight sides, and is triangular in section instead of semicircular as is more common. It is distinctly marked off from the rest of the valve.

The movable tergum is trapezoid, with the upper occludent margin parallel to the straight basal margin. The articular margin is straight except at the basal angle, where the axial ridge forms a projection. The posterior occludent margin is convex. The apex is obtuse and rounded off. The uppermost articular ridge is the broadest, and is not separated from the upper margin. The other three are subequal in width. The post-axial part of the plate is ornamented with growth ridges only.

The rostrum is shaped like a cone with a section removed. The marginal umbo lies at the junction of the fixed and movable scuta. The uppermost articulatory ridge is double and runs at the edge of the valve. The middle ridge is by far the largest. The ridges are depressed and not sharply demarcated on the lower side. The remainder of the valve is ornamented with distinct but inconspicuous growth ridges only. There are no articular ridges on the side next the fixed scutum.

The carina is rectangular, and bent medianly at rather less than a right angle. The two portions of the upper margin are straight, that nearest the rostrum articulating with the movable tergum. Three broad flat ridges, separated by shallow furrows, articulate with the rostrum. No ridges articulate with the fixed tergum, but only one irregular projecting lobe which fits into a pit on the carinal margin of the fixed tergum.

The fixed scutum is irregularly quadrilateral. The curved occludent margin is as long as, and nearly parallel to, the very irregular basal margin. The rostral margin is irregular, and runs obliquely up the side of the shell. The fixed tergal margin is nearly vertical. The apex is acute and produced. The valve is divided into two triangular portions by a line running diagonally across it from the apex. In the upper or occludent segment the growth lines are parallel to the convex portion of the rostral margin. There is a faint indication of a median ridge on this segment. The lower segment is smoother, and has less distinct growth ridges parallel to the basal margin.

The fixed tergum is divided into three triangular sections—a central paries with apical umbo and irregular growth lines, and two lateral areas. The scutal lateral portion is small and lies below the general surface of the wall ; the carinal portion is nearly as large as the paries.

The internal anatomy has not been investigated, as it would have entailed the destruction of the unique specimen of this species.

Remarks.—The species is closely allied to *V. grimaldii* Gruvel (1912), obtained by the Prince of Monaco in lat. 32° 30′ 30″ N., long 17° W., at a depth of 2380 metres. It differs, however, in the movable operculum being parallel to the basis instead of oblique, and in the absence of rostral ribs articulating with the movable scutum.

The author has pleasure in naming this new species after Mr. T. T. Macan, one of the biologists on the " John Murray " Expedition.

Suborder BALANOMORPHA Pilsbry 1916.

Family *BALANIDÆ* Darwin.

This family is represented in the collection by three genera, *Balanus*, *Acasta* and *Tetraclita*, and twelve species.

Genus BALANUS Darwin.

This large and difficult genus is represented in the collection by ten species belonging to five of the subgenera proposed by Pilsbry (1916), namely, *Megabalanus*, *Balanus* s. str., *Chirona*, *Solidobalanus* and *Conopea*.

Subgenus Megabalanus Pilsbry.

Megabalanus is represented by a single species :

Balanus (*Megabalanus*) *tintinnabulum* Darwin.

Balanus tintinnabulum, Darwin, 1854, p. 144, pl. i, figs. *a–l*, pl. ii, figs. 1*a*–1*o*.
Balanus tintinnabulum, Hoek, 1883, p. 147, pl. xii, figs. 18, 19 ; 1913, p. 164, pl. xiv, figs. 5–7.

Occurrence.—Sta. 53, South Arabian Coast, depth 13½ metres ; 6 specimens.

Remarks.—All the specimens were dead when collected and had lost the opercular valves, but they appear to be referable to this species.

Subgenus Balanus Pilsbry.

This subgenus is represented by two species:

Balanus (*Balanus*) *trigonus* Darwin.

Balanus trigonus, Darwin, 1854, p. 223, pl. iii, figs. 7*a–f*.
Balanus trigonus, Krüger, 1911, p. 49, pl. i, fig. 6, pl. iii, fig. 33, text-figs. 98–100.
Balanus trigonus, Pilsbry, 1916, p. 111, pl. xxvi, figs. 1–13*e*, text-figs. 27, 28.

Occurrence.—Sta. M.B. II (*c*), South Arabian Coast, depth 30 metres; 1 specimen attached to a fragment of a larger *Balanus*.

Remarks.—The parietal ridges are only poorly developed, probably owing to the juvenile condition of the specimen. The scuta bear three rows of oblong deep pits.

Balanus (*Balanus*) *amphitrite* var. *communis* Darwin.

Balanus amphitrite, Darwin, 1854, p. 240, pl. v, fig. 2*a–o*.
Balanus amphitrite, Nilsson-Cantell, 1921, p. 311, text-fig. 64.

Occurrence.—(i) Sta. 111, Zanzibar Area, depth 73–165 metres; 3 specimens attached to a piece of a dead Gorgonian skeleton and devoid of opercular valves, probably referable to this species.

(ii) Sta. 120, Zanzibar Area; 2 specimens purporting to come from a depth of 2900 metres.

Remarks.—Both specimens from Sta. 120 are detached from their substratum and are somewhat crushed, and moreover have rust-like concretions on the basis as if they had been attached to iron. Hence it is highly probable that these specimens come, not from 2900 metres, but were scraped off the ship's hull—a common habitat of this species—during the hauling of the net.

Subgenus Chirona Pilsbry.

The subgenus *Chirona* is represented by two species, *B. amaryllis* Darwin and *B. albus* Hoek.

Balanus (*Chirona*) *amaryllis* Darwin.

Balanus amaryllis, Darwin, 1854, p. 279, pl. vii, figs. 6*a–c*.
Balanus amaryllis, Gruvel, 1905, p. 250, text-fig. 279.
Balanus amaryllis, Hoek, 1913, p. 179, pl. xv, figs. 17–21, pl. xvi, figs. 1–4.
Balanus amaryllis, Pilsbry, 1916, p. 217.

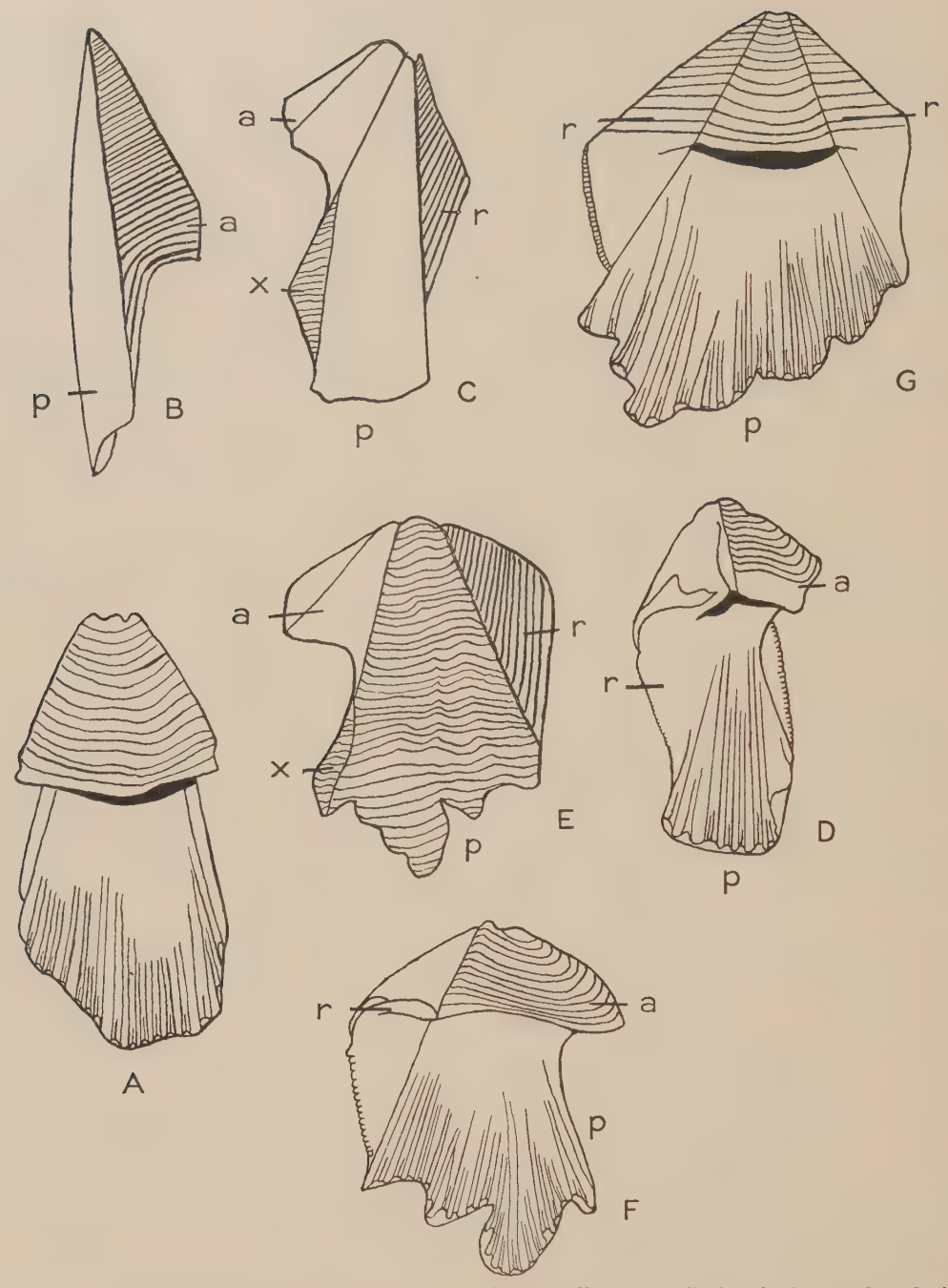
Occurrence.—Sta. 35, Gulf of Aden, depth 450 metres; 2 living specimens from the body of the crab, *Echinoplax pungens* Spence-Bate.

Remarks.—Both are of the white variety (var. *niveus* Gruvel, 1905). Pilsbry (1916) records this species from a depth of 150 fathoms, and remarks that it has an unusually great range, occurring from the surface down to this depth; but those specimens found by the "Albatross" from below 114 fathoms were all dead, which is somewhat peculiar when it is borne in mind that the present specimens come from over twice that depth.

Balanus (*Chirona*) *albus* Hoek. (Fig. 18.)

Balanus albus, Hoek, p. 185, pl. xvi, figs. 12, 13, pl. xvii, figs. 1–6.

Occurrence.—(i) Sta. 105, Zanzibar Area, depth 238–293 metres; 4 living and 6 dead examples attached to a large *Buccinum*-like Gasteropod (? *Drillia* or *Pleurotoma*).



TEXT-FIG. 18.—*Balanus albus* Hoek. The plates of the wall. A, B, Carina in internal and side view. C, D, Carino-lateral in external and internal view. E, F, Lateral in external and internal view. G, Rostro-lateral and rostrum in internal view. All × $\frac{8}{3}$. *a.*, ala. *p.*, paries. *r.*, radius. *x.*, ridged part of paries, interlocking with radius of radio-lateral.

(ii) Sta. 157, Maldive Area, depth 229 metres; 18 specimens (7 living), on *Caryophyllia* spp.

(iii) Sta. 194, Gulf of Aden, depth 220 metres; about a dozen specimens, half of which were dead, attached to Gasteropod shells, probably *Pleurotoma* sp., which also bore specimens of a small anemone and occasionally smaall sponge.

REMARKS.—Of the specimens from Sta. 105 only two, one of which was dead, are

approximately full-sized. The vertical ribs on the parietes are distinct, and on the large dead example traces of the growth ridges can be made out.

A number of other specimens, attached to pieces of clinker, from this station, are also referred to *B. albus*, though with considerable hesitation, as they are far less typical than the above specimens. In the parietes the growth lines are almost invisible except for occasional traces on the older specimens, and the vertical ridges are all but absent. The walls, however, are probably the most variable part of a *Balanus*, and so too much weight must not be put on this character. The scutum and tergum are very typical. As in the previously mentioned specimens, the basis is porous throughout, a character concerning which Hoek (1913) was doubtful in his diagnosis, and which Pilsbry (1916) was unable to settle for lack of fresh material.

Subgenus Solidobalanus Hoek.

This subgenus is represented by three species, two of which, *B. thompsoni* and *B. echinoplacis*, must be regarded as new.

Balanus (*Solidobalanus*) *ciliatus* Hoek.

Balanus ciliatus, Hoek, 1913, p. 199, pl. xix, figs. 8–16.

Occurrence.—(i) Sta. M.B. I (*d*), Red Sea, depth 26 metres ; 1 specimen attached to a piece of sponge-like substance.

(ii) Sta. 24, Gulf of Aden, depth 73–220 metres ; several specimens.

Remarks.—In the Red Sea specimens the basis is elongated and wrapped round as if to clasp a cylindrical support, only a portion of which is left as the spongy tissue in the trough formed by the basis. The radii are orange-pink and the parietes reddish, darker towards the base of the compartments, with red stripes on the upper part merging into the completely red basal part of each compartment. The carina is pinkish-white with four vertical red lines.

The articular ridge of the scutum is rather more prominent than described and figured by Hoek. The mandibles and maxillæ agree with the figures of the type-specimen.

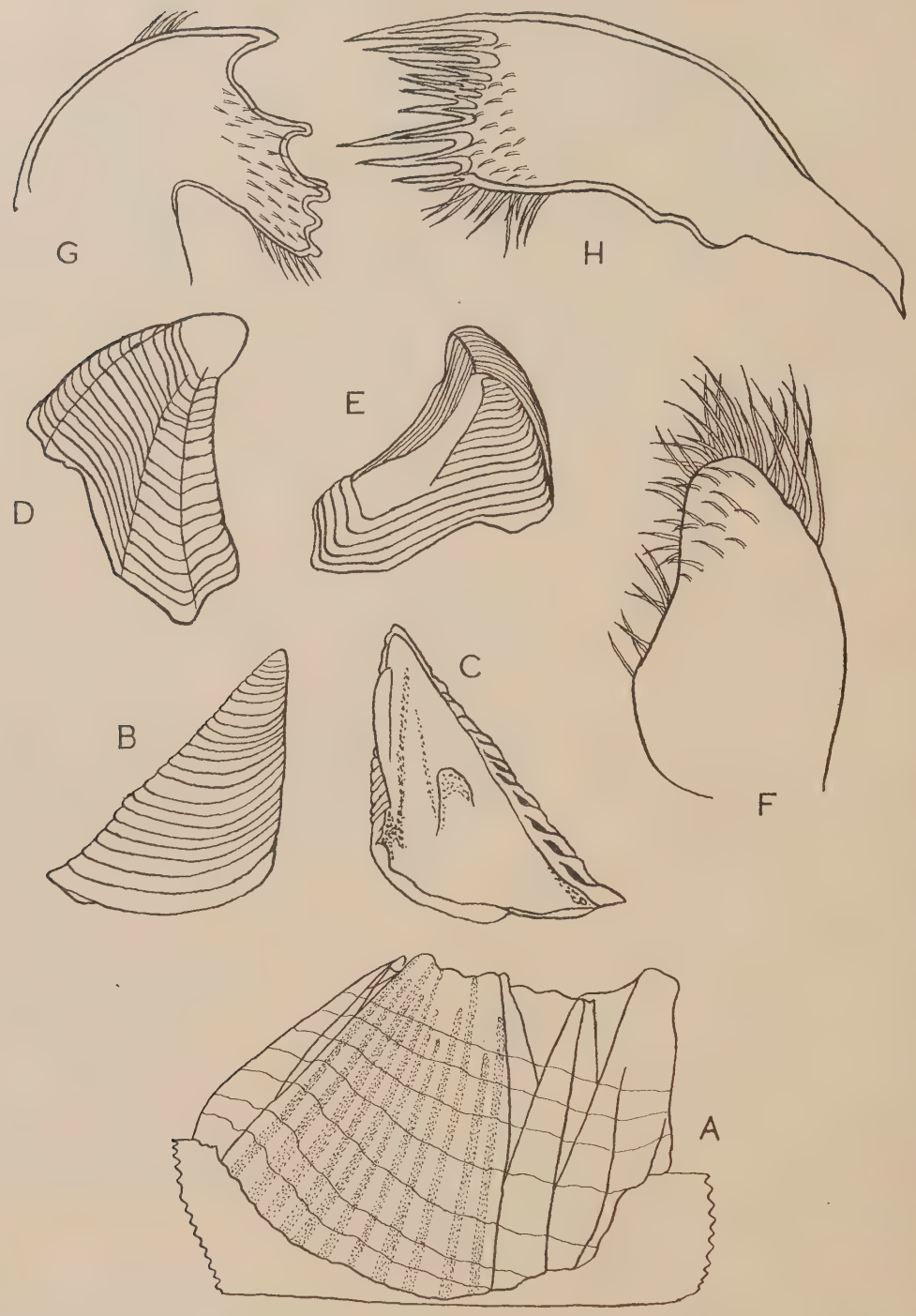
The specimens from the Gulf of Aden were attached to a hydroid that was encrusted with Foraminifera, a Stylasterine, Polyzoa, sponges, etc. Of about a dozen specimens, at least half were dead. The majority of the specimens are of the normal pale pinkish-red colour, partly white, and with vertical red stripes and an orange tinge on the radii and parts of the parietes. One specimen, however, like that from Sta. M.B. I (*d*), is orange-red all over with deep red vertical lines on the parietes.

Balanus (*Solidobalanus*) *thompsoni* sp. nov. (Fig. 19.)

Occurrence.—Sta. 24, Gulf of Aden, depth 73–220 metres ; 1 specimen.

Diagnosis.—Test white ; basis calcareous and non-porose, internally radially ribbed ; parietes of rostrum, lateral and carina, broad ; of carino-lateral, narrow ; radii very narrow with very oblique summits ; orifice pear-shaped ; apices of parietes truncated and slightly toothed ; scutum triangular, basal margin convex ; tergum with very small, broad spur, with obliquely truncated end ; apex acute and reflected over scutum ; mandible with five teeth and no ventral lobe ; third tooth double.

Description.—The basis is roughly circular and the test forms a smooth regular cone. No longitudinal ridges or growth ridges are visible externally, the only irregularities



Text-fig. 19.—*Balanus thompsoni* sp. nov. A, Type-specimen, × 20. B, C, Scutum in external and internal view, × 30. D, E, Tergum in external and internal view, × 30. F, Palpus. G, Mandible. H, Maxilla I. All × 48.

being shallow furrows between the parietes where lie the very narrow radii. The summits of the alæ are nearly parallel to the basis. The parietes have a slightly concave upper margin with a tooth at either corner, and sometimes two smaller teeth between these formed by the upper ends of internal ridges. They are non-porose and internally furrowed.

The scutum has straight occludent and tergal margins. It is ornamented externally

by regular growth ridges. There is a large articular ridge. The adductor ridge is poorly developed except below the articular ridge, where it forms a definite side to the deep triangular pit for the adductor muscle. The depressor pit is small but distinct.

The tergum has a convex occludent margin and strongly concave scutal margin. The obliquely truncated spur curves into the basal margin on the scutal side. The other side is straight and forms a wide angle with the basal margin. Internally there is a strong articular ridge running from the apex to the tip of the spur.

The palpus is oval and concave on the inner margin, which bears short, stout and somewhat strongly curved setæ.

The mandible has five teeth, the third being double. There is no ventral lobe. There are spines on the ventral margin as in all species of the subgenus *Solidobalanus*.

The first maxilla has a very small notch and two large upper spines. There are two enlarged spines on the lower portion of the margin, and a number of pairs of stiff setæ on the ventral margin.

The second maxilla bears numerous hairs on the short, broad outer lobe. The hairs on the outer margin of this lobe are very long. The inner lobe is semicircular with very few hairs.

Cirrus I : Anterior ramus twice as long as posterior.

Cirrus II : Rami subequal, both shorter than anterior ramus of cirrus I and nearly straight. The segments are rather broader than long.

Cirrus III : Rami subequal, the posterior slightly the longer. The segments are broader than long and somewhat flattened.

Cirri IV–VI : Rami long and curved and subequal. The segments are cylindrical and longer than broad.

The following table gives the number of segments in the cirri :

Cirrus.	I.	II.	III.	IV.	V.	VI.
Anterior ramus . . .	8	9	12	15	17	21
Posterior ramus . . .	15	9	9	17	21	21

There is no penis.

Remarks.—*B. thompsoni* is closely related to *B. ciliatus* Hoek (1913), *B. socialis* Hoek (1913) and *B. hawaiensis* Pilsbry (1907), all of which possess five mandibular teeth. The other species of the subgenus, *B. maldivensis* Borrodaile (1903), *auricoma* Hoek (1913), *compressus* Hoek (1913) and *tantallus* Pilsbry (1907*b*), have only three or four mandibular teeth and a lower lobe with a dentate edge. Of the three nearest, *B. hawaiensis* lacks the double third mandibular tooth and so is readily distinguished ; *B. ciliatus* has broad radii, and so is quite distinct in external features alone. There are other small differences in the appendages, *e. g.* the fifth mandibular tooth is distinct from the lower angle, but is blunt and rounded like the lower lobe ; this tooth is similar in *B. socialis*, where the third tooth is single, thus distinguishing this species from the new *B. thompsoni*.

This species is named after Mr. E. F. Thompson, one of the scientists of the " John Murray " Expedition.

Balanus (*Solidobalanus*) *echinoplacis* sp. nov. (Fig. 20.)

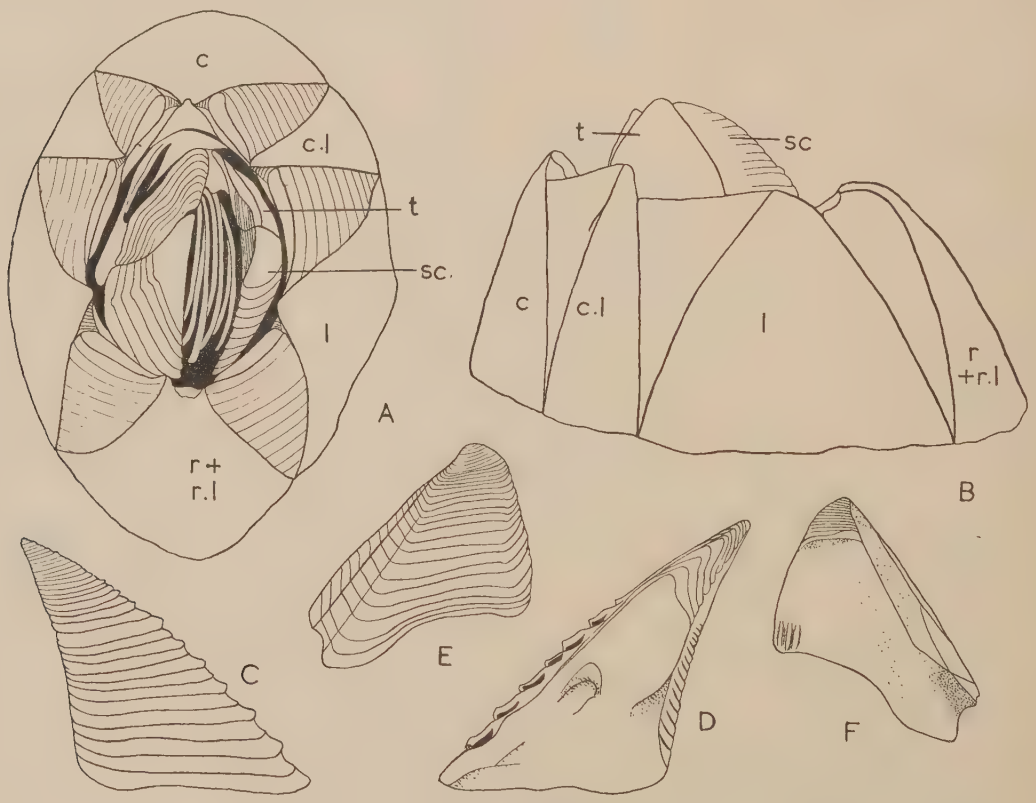
Occurrence.—Sta. 106, Zanzibar Area, depth 225 metres ; 48 specimens attached to a crab, *Echinoplax pungens* ; 31 specimens were left *in situ*.

Diagnosis.—Solid, thick-shelled balani with smooth shiny parietes and radii; parietes without striæ or distinct growth lines; radii broad with horizontal markings in the texture of the shell; summits of radii nearly parallel to basis; articular edges ridged; alæ large, but hidden by radii except at the upper angle; summits of alæ very oblique; scuta with distinct growth ridges and occasional fine intervening lines; apex slightly retroverted towards tergum; adductor pit distinct; tergum with poorly developed depressor ridges.

Description.—The form of the shell is circular, or more often oval when attached to Crustacean limbs. It is chalky white and absolutely smooth and devoid of growth lines or ridges, except in the case of one old and distorted specimen, in which three short ridges occur on one lateral paries. The parietes have acute apices, that of the rostrum curving inwards. The basis is porose with radiating canals. It is firmly attached to the Crustacean and fairly thick. The canals are large. A few regular ridges occur on the inner surfaces of the parietes. The orifice of the shell is oval, and the opercular valves project above the surface of the shell.

The scutum is triangular. The basal margin is slightly sinuous, the occludent weakly convex and toothed, and the tergal margin slightly concave. The growth lines appear as distinct grooves demarcating successive incremental areas. Alternate areas have large and small teeth on the occludent margin. The articular ridge is very prominent, the adductor ridge scarcely indicated as a convex area at the lower end of the articular ridge.

The tergum is roughly triangular, with convex carinal margin and straight scutal margin. The scutal margin is twice bent so as to form a distinct ridge, triangular in



Text-fig. 20.

section, along the scutal margin. There is no spur furrow. The spur is short and truncated with the sides curving into the basal margin. The apex of the valve is rounded, and very slightly retroverted towards the scutum. The articular ridge is prominent, with a distinct groove between it and the edge of the valve which forms a second ridge. There are small and indistinct ridges for the attachment of the depressor muscles.

The palpus is almost rectangular, not tapering, with short setæ on the inner edge and a dense tuft of longer setæ at the distal extremity.

The mandible bears four teeth, the lowermost being blunt and the others acute. There are three teeth on the inferior lobe, the lower two being very minute. There is a row of spines on the ventral edge and a few hairs on the dorsal.

The first maxilla has two large upper spines. There is a very small notch with one short spine, and below this four large spines followed by about six small ones on the lower angle.

The second maxilla has a conical outer lobe, thickly coated with hairs on the outer margin. The inner lobe is minute and rounded with very few hairs.

The rami of all the cirri except the first are subequal in length. The first cirrus is not separated from the succeeding five. The rami of cirrus I are very unequal, the long anterior ramus consisting of thirteen, the shorter posterior ramus of eight segments.

The penis is very long and finely annulated.

TEXT-FIG. 20.—*Balanus echinoplacis* sp. nov. A, Dorsal, B, lateral view of type-specimen. C, D, Scutum in external and internal view. E, F, Tergum in external and internal view. G, Palpus. H, Mandible. J, Maxilla I. K, Maxilla II. *c.*, carina. *c.l.*, carino-lateral. *l.*, lateral. *r.* + *r.l.*, rostrum + rostro-laterals. *sc.*, scutum. *t.*, tergum.

The specimens show considerable variation in the precise shape of the shell, some being very much steeper than others, with the orifice quadrilateral.

The majority of the specimens average about 8·5 mm. in the long axis, by 6·0 mm. in the short axis. There are numerous young specimens about 2·0 × 3·0 mm. The largest specimen measures 13·0 × 8·0 mm.

Remarks.—*B. echinoplacis* is nearly related to *B. astacophilus* Barnard and *B. hawaiensis* Pilsbry, both of which possess growth ridges and fine intervening lines rather more distinct than in this species. In *B. astacophilus*, moreover, the basis is ribbed, not porose as in the present species, and the alæ are only slightly oblique, whereas the present species has very oblique alæ. *B. hawaiensis* has level, horizontal alæ.

Subgenus Conopea Say.

This subgenus is represented by two species, *B. cymbiformis* Darwin and *B. navicula* Darwin.

Balanus (*Conopea*) *cymbiformis* Darwin.

Balanus cymbiformis, Darwin, 1854, p. 221, pl. iii, figs. 5*a*, 5*b*.

Occurrence.—(i) Sta. 27, Gulf of Aden, depth 27–92 metres; 7 small specimens about 4·5 mm. in length, from a finely-branched Antipatharian.

(ii) Sta. 35, Gulf of Aden, depth 453 metres; 8 specimens from a similar Antipatharian.

Remarks.—The specimens from Sta. 27 have the scutal and carinal margins of the tergum meeting at less than 90°. The tergum thus resembles, to some extent, that of *B. calceolus* Ellis. In the examples from Sta. 35 the majority have the angle between these sides of the tergum approximately 90°, and are typical *B. cymbiformis*.

Balanus (*Conopea*) *navicula* Darwin.

Balanus navicula, Darwin, 1854, p. 221, pl. iii, figs. 6*a–d*.
Balanus navicula, Hoek, 1913, p. 223, pl. xxii, fig. 26, pl. xxiii, figs. 1–3.

Occurrence.—Sta. 24, Gulf of Aden, depth 73–220 metres; 1 specimen, lacking opercular valves.

Remarks.—The specimen is covered with the light brown horny skeleton of the Antipatharian on which it grew, completely obscuring the purple hue of the barnacle itself. The shell is only slightly elongated.

Genus ACASTA Leach.

This genus is represented by a single species found embedded in a sponge. The species is—

Acasta cyathus Darwin.

Acasta cyathus, Darwin, 1854, p. 312, pl. ix, figs. 3*a–c*.
Acasta cyathus, Annandale, 1906, p. 144.

Occurrence.—Sta. M.B. I (*c*), Red Sea, depth 24 metres; 2 specimens, one of which is practically full-sized.

Remarks.—The larger specimen is about as broad as long, but the smaller one is considerably elongated. Both are of a deep pink colour. Both specimens are dead, having been buried in the sponge which fills the shell cavity.

Genus TETRACLITA Schumacher.

This genus is represented by—

Tetraclita porosa var. *communis* Darwin.

Tetraclita porosa var. *communis*, Darwin, 1854, p. 329, pl. x, fig. 1*a*.
Tetraclita squamosa, Pilsbry, 1916, p. 249.
Tetraclita squamosa var. *stalactiferâ*, *idem*, p. 254, pl. lix, figs. 1–5*b*.

Occurrence.—Hallaniya Island, Kuria Muria group, Arabian Sea; about 6 specimens growing upon one another, apparently broken off from a larger colony of the species.

Remarks.—The colony was growing near high water mark. Associated with it are numerous small specimens of *Chthamalus stellatus* (Poli).

Family *CHTHAMALIDÆ*.

Chthamalus stellatus (Poli).

Chthamalus stellatus, Darwin, 1854, p. 455, pl. xviii, figs. 1*a–h*.
Chthamalus stellatus, Weltner, 1897, p. 443.

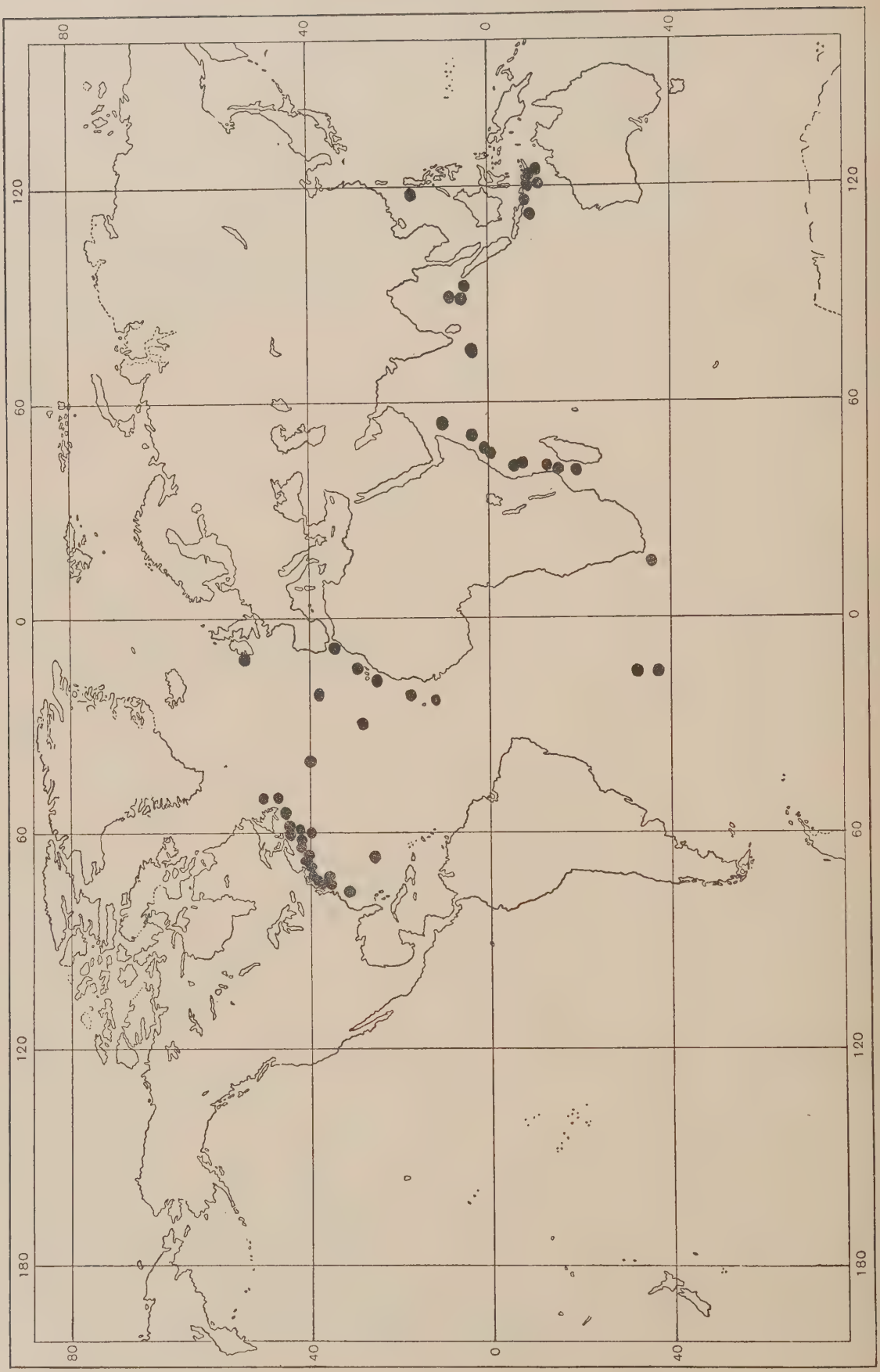
Occurrence.—Hallaniya Island, Kuria Muria group, Arabian Sea; numerous specimens.

Remarks.—A number of small specimens were obtained attached to the group of specimens of *Tetraclita porosa* mentioned above. The specimens are quite typical, but are almost certainly young.

THE DISTRIBUTION OF SOME SPECIES OF *SCALPELLUM*.

1. Geographical.

Any attempt at an account of the geographical distribution of the species of *Scalpellum* is necessarily hampered by the very sketchy nature of our knowledge of even a single species of the scores now known to science. This lack of knowledge is due mainly to the very few records that are available for any particular species, owing to the difficulty of obtaining animals from great depths without elaborately equipped vessels. From such records as we have, however, it would appear that a few species are almost world-wide in their distribution. *Scalpellum velutinum* is one of the better-known examples of a world-wide form. Fig. 21 shows the distribution of this species. The frequency of occurrence in a few areas, *e. g.* Altantic coast of N. America, is due largely to the greater detail in which such areas have been worked. It does not necessarily prove that the species is exceptionally abundant in these areas. The records of the species from the Atlantic seaboard of N. America are due to the intensive investigation of this area, extending over several years, by the U.S. Fisheries research vessel " Albatross ". The little cluster of records from the area about Madeira and the Cape Verde Islands is, again, due to the fact that this area has been worked by several research vessels, namely, the " Travailleur ", " Talisman ", and those of the Prince of Monaco. A third group of records occurs in Malaya, where the " Siboga " Expedition worked certain areas



Text-fig. 21.—Distribution of *Sc.* (*Scalpellum*) *velutinum* Hoek.

in some detail. A number of records are available for the East coast of Africa, especially north of Zanzibar, where several vessels in the past and latterly the "John Murray" Expedition have operated. Other records of the species are more or less isolated, largely owing to the incomplete working of the areas by earlier expeditions. Thus the "Challenger" obtained *Sc. velutinum* at two stations in the neighbourhood of Tristan d'Acunha, but did not make another station anywhere near.

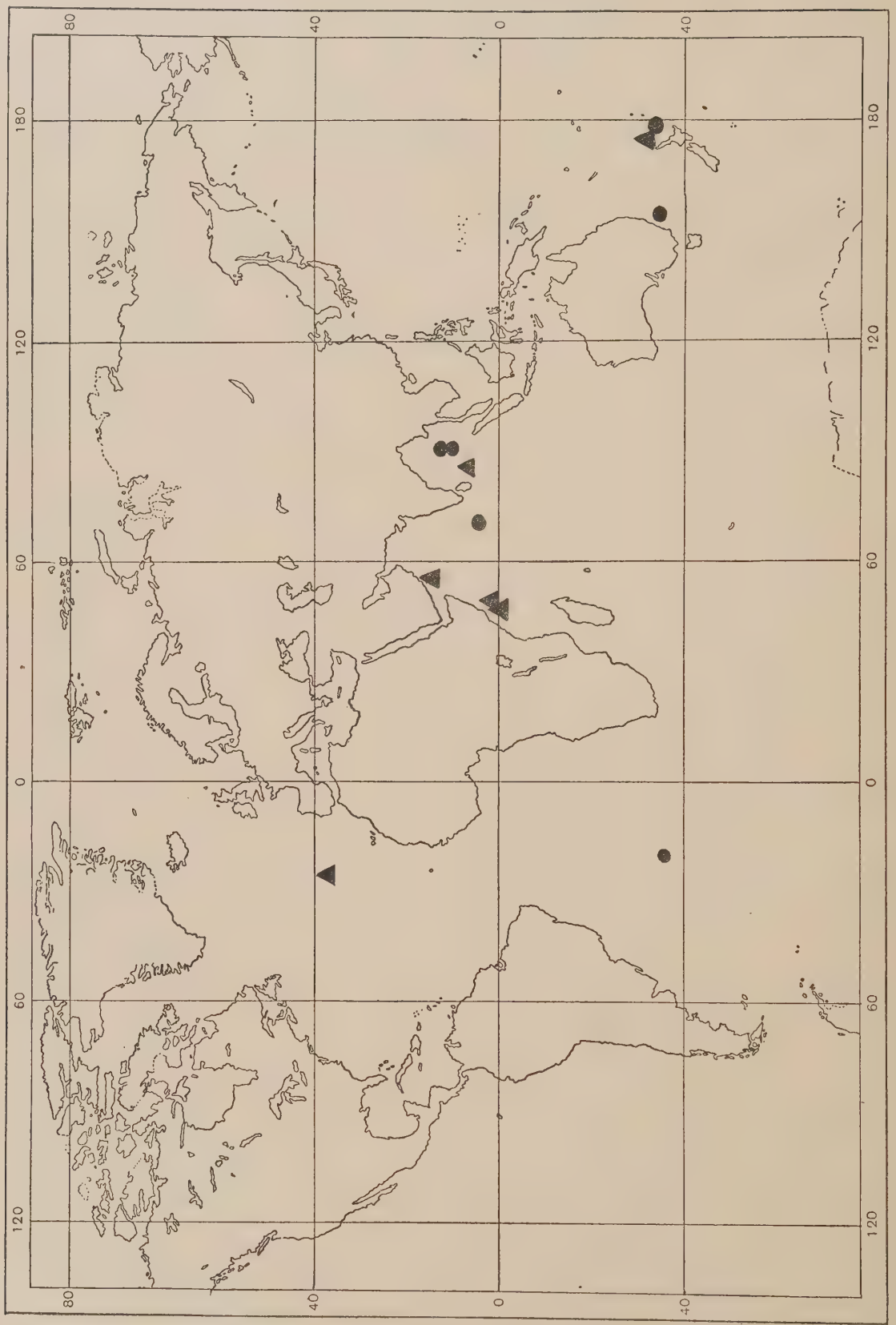
The species has been recorded as far north as lat. 51° 22′ N. (Annandale, 1911), but nowhere else in the extreme North Atlantic, except Newfoundland. The northward extension of the species to the British coast can, probably, be attributed to the northward flow of the Gulf Stream, which bathes the Irish coast in particular. In fact the whole known distribution of *Sc. velutinum* in the North Atlantic lies on the course of the Gulf Stream. Only very little of this current penetrates the English Channel, and it is fairly safe to assume the absence of this species from this locality, as this has been worked in very considerable detail by the Plymouth Marine Biological Station without a single specimen being brought to light. The species also appears to be absent from the North Sea, but it is quite probable that it may yet be recorded from the neighbourhood of Iceland and Greenland, as the Gulf Stream would carry the planktonic larvæ to the east coast of Iceland, and another branch of the same current to the west coast of Greenland.

South of the equator the known limit of the species is about 40° S., specimens being recorded from Tristan d'Acunha and off the Cape of Good Hope. It is probable that this is the true southern limit of the species, as approximately in this latitude the warm sub-tropical water meets the northerly flow of the cold antarctic water, this latter dipping down under the warmer water to reach the bottom. Hence here the bottom water is probably too cold for the species to develop.

The rarity of this species in the Laccadive Sea is rather significant; the "Investigator" has trawled in this area on numerous occasions (some forty-five), and yet the species has only been obtained once at "Investigator station" 232, lat. 7° 17′ 30″ N., long. 76° 59′ 30″ E. It also appears to be completely absent from the Bay of Bengal and Andaman Sea.

The other large gap in the distribution of *Sc. velutinum*, namely, the southern Indian Ocean and the vast expanse of the Pacific, can probably be ascribed to the unexplored nature of these oceans. One may feel confident that when they are explored, this species will be shown to occur certainly in the Indian Ocean down to about 40° S., and most probably in the Pacific, as it has already been recorded from the extreme west of this latter ocean in the Philippine Islands.

It is interesting to note that geographically the distribution of *Sc. velutinum* can be divided into two main regions—(1) the Malay Archipelago, Indian Ocean and South Atlantic, and (2) the North Atlantic. The two regions are separated by the whole of the Tropical Atlantic from the Cape Verde Islands to a little to the north of Tristan d'Acunha. The two areas belong to separate ocean current systems. The Indian Ocean distribution can be explained by the alternating monsoon drifts and the south equatorial current. The Agulhas current would carry the species southwards as far as the Cape of Good Hope. Hence, the distribution of the species into the South Atlantic could only occur by the northerly flowing Benguela current, which, however, is a much cooler current formed by the mingling of water from two easterly currents, the warm South Atlantic current and the more southerly cold Antarctic current.



Text-fig. 22.—Corresponding distribution of the two species *Sc. elongatum* Hoek and *Sc. novæ-zelandiæ* Hoek.
Sc. (Scalpellum) elongatum ● *Sc. (Scalpellum) novæ-zelandiæ* ▲

The problem is, how does a planktonic animal get transferred from the Agulhas current to the Benguela current, since the bulk of the former turns southwards over the Agulhas Bank and then flows back eastwards ? Meisenheimer (1905) has propounded a theory of a " Südafrikanisches Mischgebiet " to the south-west of the Cape of Good Hope, but very definitely excludes the warm Agulhas current from this mixing on his chart (*ibid.*, Karte IX). However, Gerhardt Schott (1926, p. 105) gives a chart of the Cape of Good Hope and Aulghas Bank in which he indicates a branch of that current swinging round the Agulhas Bank and flowing in a north-westerly direction. In a later publication the same author (1935, p. 234) says of the Agulhas current : " Ein kleinerer Prozentsatz gelangt in höchst eigenartiger Weise südlich von den Agulhas-Bank und auch über die Bank hinweg am Kap der Guten Hoffnung entlang hinaus in den Atlantischen Ozean, gegen die während vieler Monate an der Südspitze Afrikas herrschenden Westwinde fliessend. Dass dies der Fall ist, dass er in dieser Weise sich als Druckstrom nach Westen durchsetzt, kan nur durch seine vom Indischen Ozean mitgebrachte gewaltige Energie erklärt werden." Gerhardt Schott here publishes two detailed charts of this current for the southern winter (*ibid.*, fig. 64) and southern summer (*ibid.*, fig. 65), in which this north-westerly branch can clearly be followed.

Hence, we have a direct, though small, current link between the two oceans by which inhabitants of the Indian Ocean may be transferred to the Southern Atlantic. This north-westerly current would carry the pelagic animals into the Benguela current and so northwards into tropical waters again, and at its northern end into the south equatorial current of the Atlantic. From here the species could be carried southwards again by the Brazil stream and would ultimately reach Tristan d'Acunha.

The North and South Atlantic current systems are connected by a considerable north-westerly current, part of the South-East Trade or South Equatorial current, flowing up the North-East coast of South America and joining with the North Equatorial current before entering the West Indian area. It is highly probable that this was the line of extension of the distribution of *Sc. velutinum* into the North Atlantic, but at present there is nothing to prove conclusively that the species can exist in this immense intermediate zone, and it has not been recorded from the Sargasso Sea.

No other species is known from so many localities. A number, however, are known from widely separated stations, and it seems probable that these stations may one day be linked up by further discoveries consequent upon the more thorough investigation of the oceans. *Sc. elongatum* Hoek will illustrate the point. It is known from Auckland, New Zealand ; off Sydney, Australia ; the Bay of Bengal ; the Maldive Archipelago ; and one isolated station off Tristan d'Acunha. This distribution strikingly coincides with that of *Sc. novæ-zelandiæ* Hoek, which has been recorded from very similar localities. The distribution of this latter species differs in that it has not been recorded from Sydney, Tristan d'Acunha or the Maldives, but it occurs in the Gulf of Aden (Fig. 22), off Portugal and on the East African Coast.

This widespread distribution may possibly be explained by assuming a centre of distribution in the Western Pacific. Thence the Pacific Southern Equatorial current would carry the species to the east coast of Australia and to the North Island of New Zealand, but perhaps not to the South Island, where it is possible that conditions are unfavourable for the two species, owing to the cold Antarctic currents round that island. Part of the Southern Equatorial current, flowing through the East Indies, would carry

Text-fig. 23.—Distribution of *Sc. pacificum* Pilsbry, *Sc. minutum* Hoek, and *Sc. abyssicola* Hoek.
Sc. (Scalpellum) pacificum ■ *Sc. (Scalpellum) minutum* ● *Sc. (Scalpellum) abyssicola* ▲

the species into the Indian Ocean, where their further distribution would take place in a manner similar to that put forward for *Sc. velutinum*.

Scalpellum minutum is a species offering a problem in distribution that appears insoluble in the present state of our knowledge. It was first obtained by the " Challenger " off Chili in lat. 42° S. Since that date it has not been found until recorded by the present expedition from off Zanzibar.

The conditions of life in these two widely separated areas are somewhat different, though both regions are cooled by cold antarctic water. The Chilean specimen was obtained at a depth of 1450 fathoms (2677 metres), and a temperature of only 1·5° C., whereas the present specimen comes from less than a third of that depth, 802 metres, and a bottom temperature of 7·8° C. Despite the somewhat big difference between them, the two sets of conditions would indicate that *Sc. minutum* is a species that inhabits cold waters.

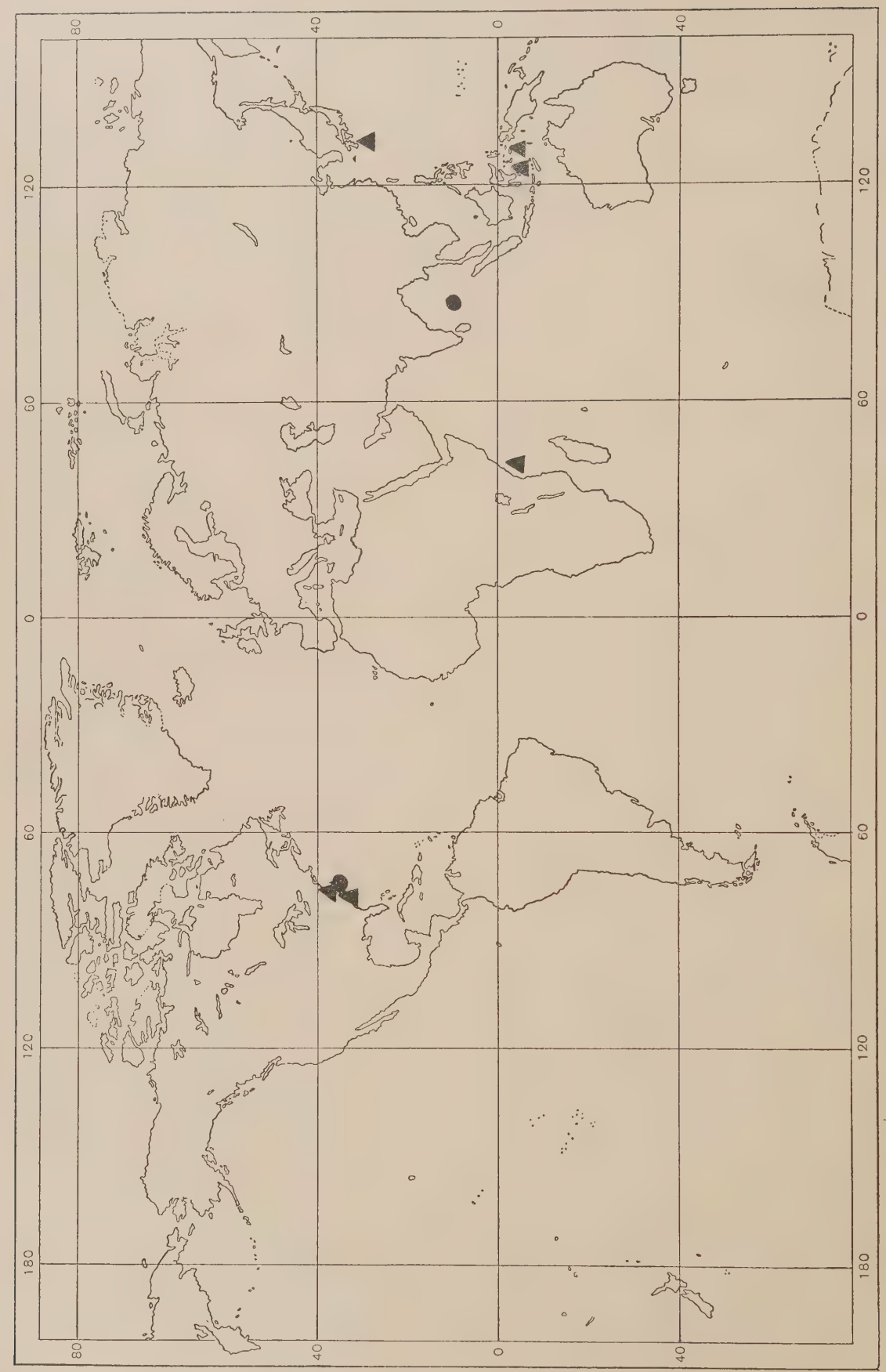
There are two possible explanations of the distribution. It may be that this is an East Indian species that has spread westwards across the Indian Ocean, and eastwards across the whole width of the Pacific Ocean to the American coast. In the unlikely event of this being true, it is curious that *Sc. minutum* was not obtained either by the " Siboga " Expedition to the East Indies, or by Mortensen's expeditions to Australia and the Pacific. Moreover, such a line of distribution argues a species capable of living at a comparatively high temperature, of which we have no evidence, the available data all pointing to a low temperature.

The other alternative is to assume that *Sc. minutum* is an Antarctic form that has spread northwards along the northerly antarctic currents. This would fit in with the known temperatures at which the species was collected, and with the known movements of the antarctic bottom water : the cold Peru current, flowing up the west coast of South America, and the bottom current that flows northwards between Madagascar and the Seychelles, overlain by the oppositely moving Agulhas current, and traces of which can be found as far north as Mombasa.

From examples such as this one cannot but feel that the true deep-sea species of *Scalpellum* are extremely hardy and can stand a considerable range of temperature. In particular must this be true of the larvæ for, being planktonic, they doubtless experience greater variations of temperature than the bottom-living adults which inhabit a region where conditions remain almost constant throughout the year.

Scalpellum abyssicola is only known from the Gulf of Aden and the Pacific Ocean east of Japan. Here again we can only surmise that it occurs in the intervening area, but has not yet been recorded there. If this should be so it is remarkable that it has not been found in the Arabian Sea or Bay of Bengal, both of which areas have now been thoroughly worked. The species has apparently a large vertical range in deep water, so there is no apparent reason for its absence from at least the deeper parts of the above areas.

One other species, for which widely separated localities are known, is represented in the present collection. *Sc. formosum* was first described from Malayan specimens, and is at present known also from Zanzibar and from Cape Hatteras on the Atlantic coast of North America. Once again we have to invoke the aid of Meisenheimer's " Südafrikanisches Mischgebiet " and the Agulhas current to provide a means of entry into the Atlantic Ocean of an Indian Ocean species.



TEXT-FIG. 24.—Distribution of *Sc. albatrossianum* Pilsbry and *Sc. formosum* Hoek.
Sc. (Scalpellum) albatrossianum ● *Sc. (Scalpellum) formosum* ▲

Besides these widespread species of *Scalpellum* there are in the Indian Ocean a considerable number of species, not less than sixteen, that are known only from this ocean and the Malay Archipelago.

In the following list I have classified the known Indian species into four groups based on their areas of distribution as at present known :

(1) Indian Ocean and Malay Archipelago only :

Smilium kampeni.
Euscalpellum bengalense.†
E. rostratum.
E. squamuliferum.
Scalpellum alcockianum.
Sc. annandalei.
*Sc. curiosum.**
Sc. diota.
Scalpellum elegans.
Sc. gruvelii.
Sc. laccadivicum.
Sc. lambda.†
Sc. longius.
*Sc. sociabile.**
Sc. trapezoideum.
Sc. wood-masoni.†

(2) Indian and Pacific Oceans :

Scalpellum abyssicola.
Sc. minutum.
Sc. pacificum.

(3) Indian Ocean and North Atlantic :

Smilium acutum (also in Australasia).
Scalpellum albatrossianum.
Sc. formosum (and off Japan, Nilsson-Cantell, 1921).

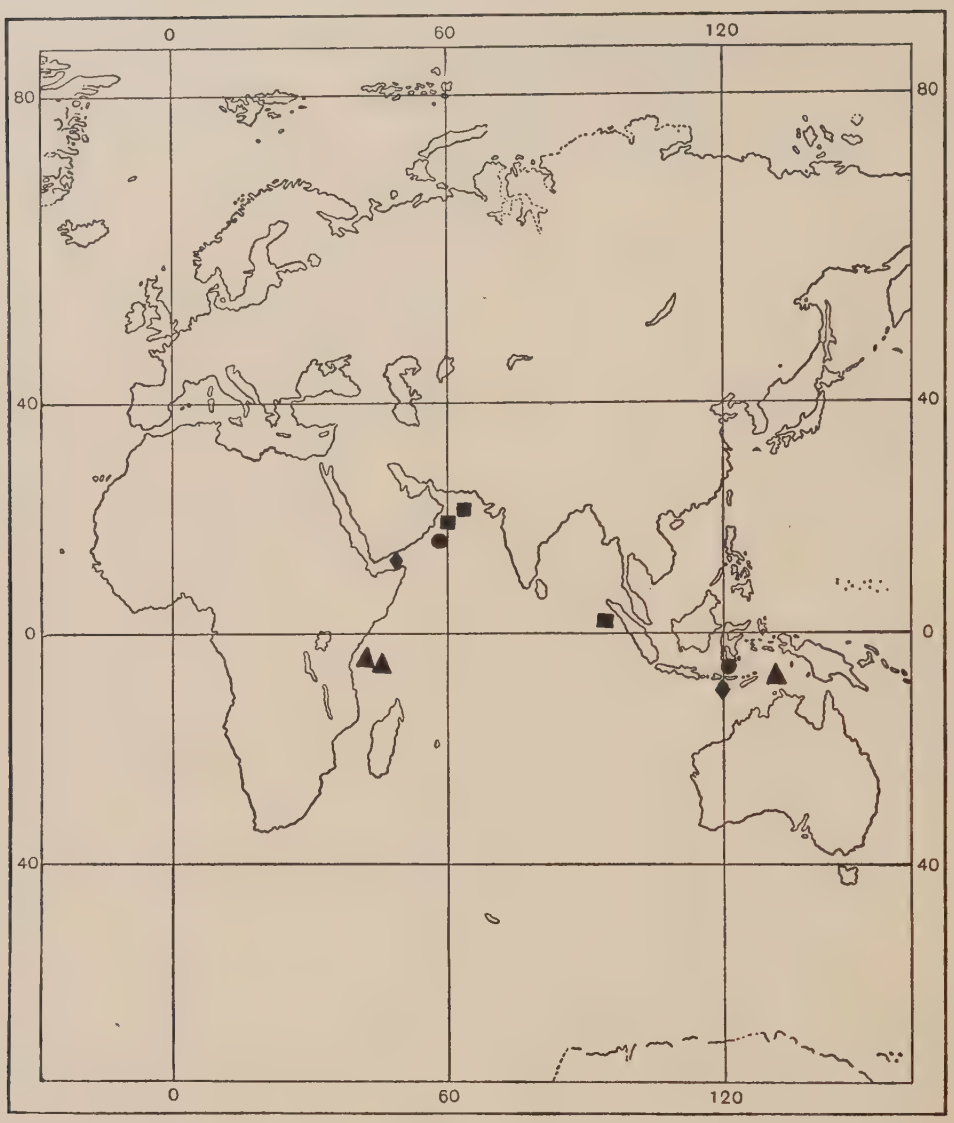
(4) Indian Ocean, South Atlantic and Australasia :

Scalpellum elongatum.
Sc. novæ-zelandiæ.

Thus rather more than half the species of *Scalpellum* recorded in Indian waters have not been found outside the Indo-Malayan region, and all are recorded from comparatively near the land, and none from mid-ocean.

The species *Euscalpellum squamuliferum* seems to be almost confined to the Bay of Bengal. There is a single published record of this species from Singapore. Along the Malay Peninsula, especially at the southern end and in the Gulf of Siam, it is largely replaced by *S. kampeni.* The latter species, however, inhabits somewhat shallower water. *S. kampeni,* in turn, is replaced almost completely by *Sc. rostratum* in the Malay Archipelago. *Sc. rostratum,* however, is a very shallow water form and is almost littoral in its distribution. Both *S. kampeni* and *Sc. rostratum* have, however, been recorded outside the Malay region, being obtained by the present expedition from the Arabian Sea. *Sc. rostratum* has also been recorded from the Philippines (Darwin, 1851). Hoek in his report on the " Siboga " Collection suggests that *Sc. rostratum* is probably one of the commonest species under the tropics, and the extension of its known area of distribution westwards to the Arabian Sea certainly tends to bear out this assertion.

* Malay Archipelago only. † Indian Ocean only.



Text-fig. 25.—Distribution of *Sc. elegans* Hoek, *Sc. diota* Hoek, *Sc. wood-masoni* Annandale and *Sc. annandalei* Calman.

Sc. (*Scalpellum*) *elegans* ● *Sc. Scalpellum*) *diota* ▲ *Sc.* (*Scalpellum*) *woodmasoni* ■
Sc. (*Scalpellum*) *annandalei* ◆

It is perhaps worthy of note that the majority of the species listed above appear to inhabit only moderately deep water, none being truly abyssal. The species of *Smilium* and *Euscalpellum* in particular seem to prefer comparatively shallow water. However, the majority of these species have been obtained only after prolonged investigation of a confined area. The low efficiency of the deep-sea trawl as a means of investigating the bottom fauna is generally recognized, as is also the patchy nature of the bottom fauna. It is obvious, therefore, that a single haul cannot give a complete qualitative estimate of the fauna of any given area. With such comparatively rare animals as many of the species of *Scalpellum* it is more the exception than the rule to obtain them in the trawl, and until really detailed work is done in a particular locality it cannot be said with any

TEXT-FIG. 26.—Distribution of the Indian species of *Smilium* and *Euscalpellum*, *S. acutum* Hoek, *S. kampeni* Annandale, *Sc. bengalense* Annandale, *Sc. rostratum* Darwin and *Sc. squamuliferum* Annandale.

Sc. (*Smilium*) *acutum* ◆ *Sc.* (*Smilium*) *kampeni* ■ *Sc.* (*Euscalpellum*) *bengalense* + *Sc.* (*Euscalpellum*) *rostatrum* ▲
Sc. (*Euscalpellum*) *squamuliferum* ●

confidence that this or that species is absent from the area. Hence there is reason to expect that at some future date some at least of these species will be shown to have a much greater range than is at present supposed.

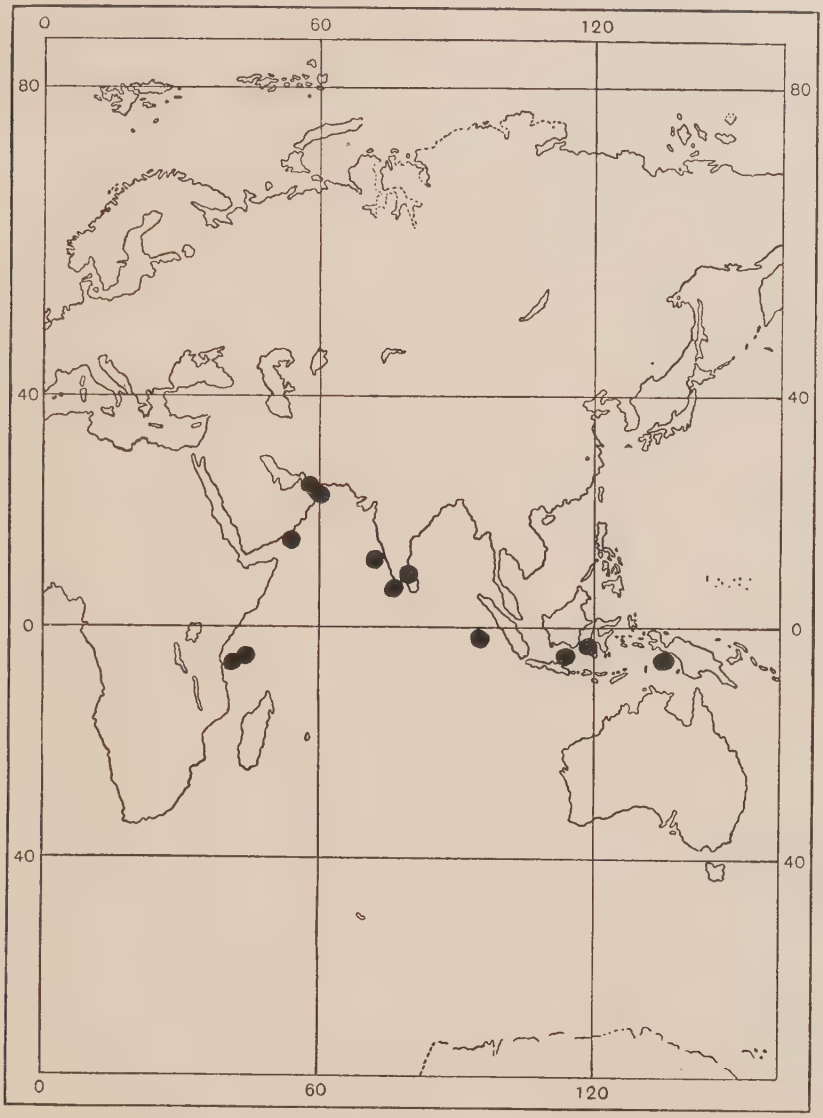
Text-fig. 27.—Distribution of the nearly related species *Sc. longius* Annandale and *Sc. lambda* Annandale.

Sc. (*Scalpellum*) *lambda* ▲ *Sc.* (*Scalpellum*) *longius* ●

A further point arising out of the distribution of the above species is the position of the two species, *Sc. lambda* and *Sc. longius*. The "Investigator" found these two species at two comparatively near stations, *Sc. lambda* in 1187 metres and *Sc. longius* in 240–462 metres. The present expedition found both species together in 762 metres. Thus the vertical distribution of these two species can be taken roughly as—

Sc. lambda, 750–1200 metres.
Sc. longius, 240–800 metres.

Annandale says regarding the validity of these species (1913, p. 235): "Possibly *Scalpellum longius* . . . is merely a complete form of *Sc. lambda*, but the structure and position of the posterior basal parts of the carinal latera of the two forms are very



TEXT-FIG. 28.—Distribution of *Sc.* (*Scalpellum*) *laccadivicum* Annandale.

different; in *Sc. lambda* these meet over the base of the carina and have the shape of regular isosceles triangles in contact for the whole of their bases and their surface is smooth. Unless or until intermediate specimens are obtained, the two must, therefore, be regarded as specifically distinct. The greater relative height of the capitulum is quite probably an inconstant feature."

Two hypotheses are thus open to us; either (1) *Sc. longius* and *Sc. lambda* are to be regarded as the same species, the differences being due to the adjustment of the latter to increased depth and pressure, by reduction of the valves, or, alternatively (2),

they are two distinct but closely allied species, one (*Sc. longius*) living above 800 metres, below which it is replaced by *Sc. lambda*.

If the second should prove to be correct, we may expect at some future date to find *Sc. longius* in still shallower water, but not in deeper water than about 800 metres. Likewise we may expect to find *Sc. lambda* in still deeper water bordering on the abyssal zone.

It is, of course, possible that the "Investigator" specimen of *Sc. longius*, recorded from 240–462 metres, may have come from the deep end of this trawling. If we accept this assumption, the bathymetrical ranges of the two species almost coincide, 460 metres being merely an upward extension of the distribution of *Sc. lambda*, which at present stands at 750–1200 metres approximately. If this be so, there is considerable justification for combining the two so-called species as one under the name *Sc. lambda*, which has priority, although no intermediate specimens have as yet been found, and which, as Annandale points out (*vide supra*, p. 61), are necessary before a final settlement of the question can be arrived at.

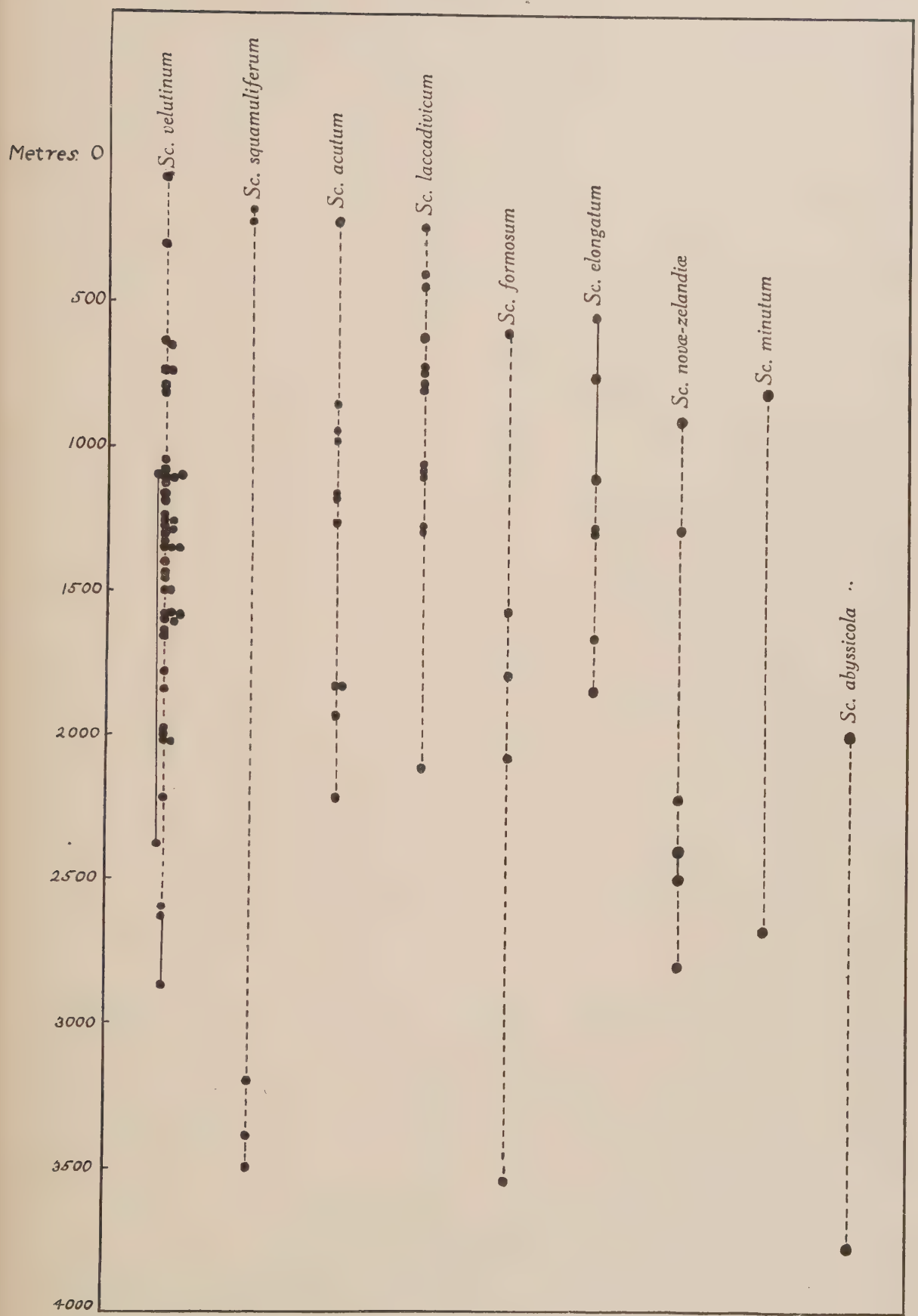
In contrast with the limited distribution of the species of *Smilium* and *Euscalpellum* (*S. kampeni*, *Sc. bengalense*, *Sc. rostratum*), collected by the expedition, and of *Sc. squamuliferum*, is that of another Indian species, *S. acutum*. In Indian waters *Smilium acutum* is known only from the Gulf of Aden. Eastwards, however, it has been found in several localities in the Malay Archipelago and the Philippine Islands and at two stations off New Zealand. The species has also been obtained in the Atlantic from the Cape Verde Islands, the Azores and the Coast of Portugal. This species of *Smilium* may thus have an almost world-wide distribution, whereas most of the species of *Smilium* and *Euscalpellum* are confined to comparatively small areas (Fig. 26). It seems that the centre of origin of this species probably lies in the East Indies, and that it has spread westwards across the Indian Ocean and southwards down the African coast, and has contrived to round the Cape of Good Hope, getting carried northwards by the cold Benguela current like *Sc. velutinum* and *Sc. minutum*.

Very little is known as to the distribution of the remaining species of *Scalpellum* from Indian Seas, but not represented in the present collection (eight in all), and it is unwise to surmise as to their possible world distribution. Mention may be made, however, of two that are apparently of wide distribution, *i. e. Sc. albatrossianum* from the Bay of Bengal and Cape Hatteras, and *Sc. pacificum* from Cape Comorin, the Gulf of Oman and the vicinity of Hawaii.

2. Bathymetrical.

Here again we are faced with the same handicaps as in discussing the geographical distribution, namely, the lack of sufficient data. For many species we have records of it having been taken at varying depths. Many of these records are separated by a vertical gap of several hundred metres. We thus get a very rough idea of the total range of a species, but as a rule we have insufficient data to more than guess at the optimum depth for a species.

The interesting case of the closely allied species *Sc. lambda* and *Sc. longius* has been discussed in the preceding section. A number of other interesting cases of species with the same geographical and/or bathymetrical distribution are known. *Sc. elongatum*,



TEXT-FIG. 29.—Vertical distribution of species of *Scalpellum* occurring at depths greater than 2000 metres.

as far as we know from existing records, has a vertical distribution of from 550–1840 metres. *Sc. novæ-zelandiæ*, however, which has very nearly the same geographical distribution, has a rather different vertical distribution. It is unknown above 900 metres, but extends downwards half as far again as *Sc. elongatum*, having been recorded from 2800 metres west of Sumatra. Here it is possible that we are dealing with two species acclimatized to slightly different conditions of pressure and attendant factors, the one (*Sc. novæ-zelandiæ*) being adapted to almost abyssal conditions, and the other (*Sc. elongatum*) to comparatively shallow waters. If the scanty records can be stretched so far, the author would suggest that *Sc. novæ-zelandiæ* is a deep-sea species, having its habitual range below 1500 metres (say 1500–3000 metres), and that it extends upwards from that depth, overlapping the lower limits colonized by *Sc. elongatum*. The latter species seems to find a depth of 700–1500 metres most suited to its requirements, and extends upwards and to a lesser extent downwards from this zone.

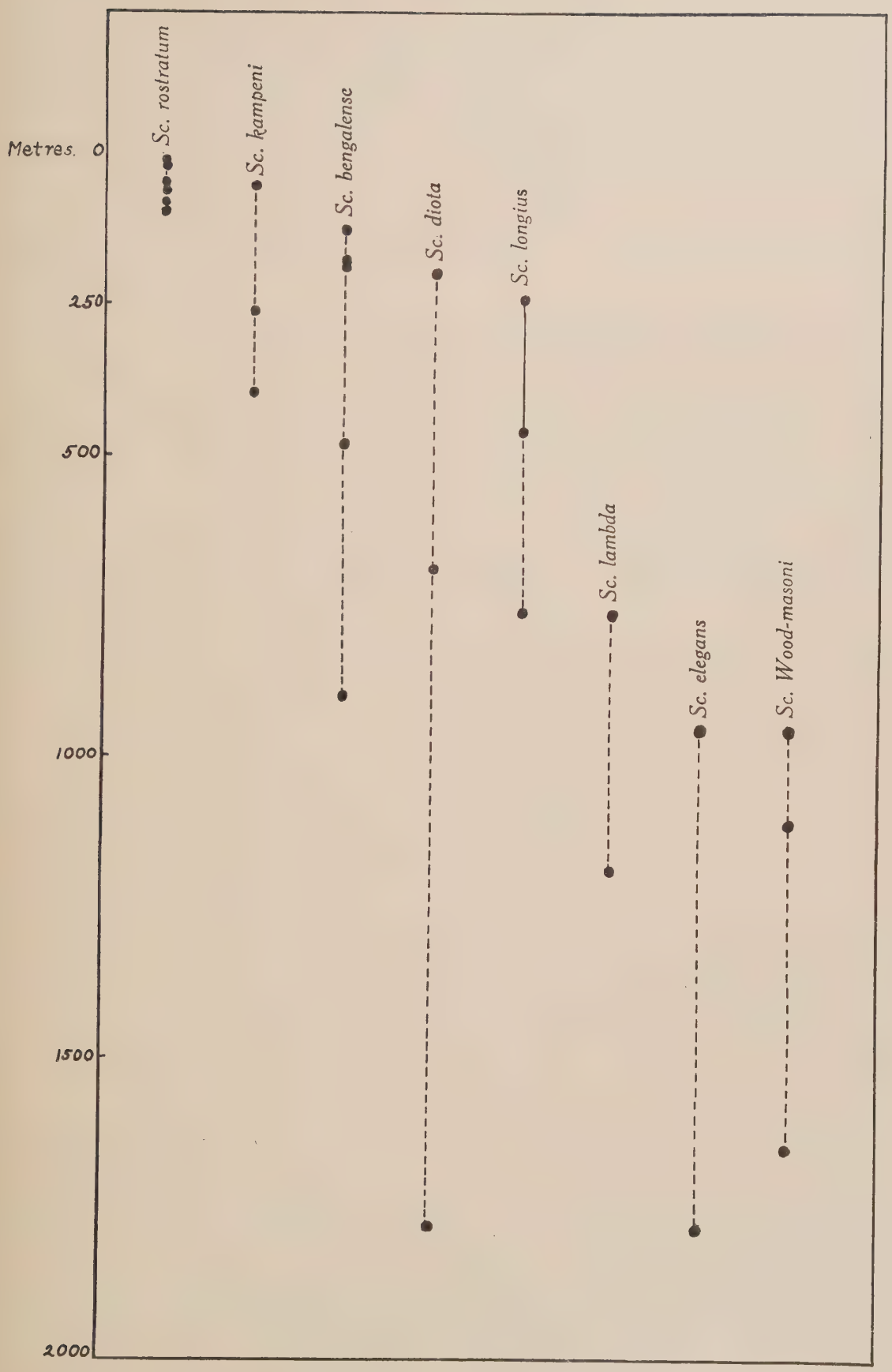
A very interesting diagram (Fig. 29) can be constructed to show the vertical distribution of *Sc. velutinum*, for which species a great number of localities are known, extending over most of the world. It has an extreme recorded range of 50–2900 metres, but, as the diagram shows, the majority of the records fall between 600 and 2000 metres, indicating fairly conclusively that this is the usual zone inhabited by this species. This very considerable range over which the species is capable of flourishing no doubt goes a long way towards accounting for the extraordinary abundance of this species in the seas of the world. *Sc. velutinum* is probably the most abundant and most widespread of all the species of *Scalpellum*.

Several species have been recorded from depths far outside what appears to be the ordinary bathymetrical range : for instance, *Sc. laccadivicum* has been taken a number of times between 250 and 1300 metres. There is, however, a solitary record of the species from over 2100 metres—800 metres deeper than any other record. Such discrepancies in depth are apt to make one hesitate before accepting the identification as correct. However, when the record comes from the pen of the founder of that species there can be little question of accepting the record as correct, and one must take it as another instance of the extraordinary adaptability of individual species of *Scalpellum*. Precisely similar instances may be quoted for *Sc. formosum*, known from 600, 1575, 1800, 2100 and 3540 metres approximately. Here the centre of distribution seems to be about 1500–2100 metres ; yet a single record is known from 900 metres above this and another more than 1400 metres below !

Of the twenty-five Indian species so far recorded, only five, *Sc. alcockianum* Annandale, *Sc. annandalei* Calman, *Sc. abyssicola* Hoek, *Sc. trapezoideum* Hoek and *Sc. albatrossianum* Pilsbry are known solely from below 1000 metres. Of these *Sc. albatrossianum* is the most remarkable, having a very small known range of only 100 metres, from 3687 to 3775 metres, although recorded from the North Atlantic and Bay of Bengal. It occurs far below all the other species, except *Sc. abyssicola*, which extends down to 3800 metres, but the latter has a much greater vertical range of 1800 metres from 2000 metres downwards.

A few other species apparently extend below the 3000 metre line, *e. g. Sc. squamuliferum*, 180–3500 metres, and *Sc. formosum*, 600–3540 metres ; but these are rather inhabitants of more moderate depths down to about 2000 metres.

No less than fourteen species do not occur above the 500 metres line, but they extend



TEXT-FIG. 30.—Vertical distribution of species of *Scalpellum* occurring at depths less than 2000 metres.

downwards to very varying depths, having a vertical range varying from 450 metres (*Sc. lambda*) to 3000 metres (*Sc. formosum*). Eight of the remainder occur below 100 metres, and go down to depths varying from 750–3500 metres. Two of the remainder, *S. kampeni* and *Sc. rostratum*, are littoral forms occurring from a few metres downwards but not below 500 metres. The ubiquitous *Sc. velutinum* occurs in 40 metres, but is here far above its usual depth, and has only once been taken in such shallow water.

The following list shows the maximum known range of the various species recorded from Indian waters, arranged in order of depth, beginning with the shallow-water forms:

Scalpellum (*Euscalpellum*) *rostratum* Darwin, 1851, 10–100 m.
Sc. (*Smilium*) *kampeni* Annandale, 1909*b*, 25–415 m.
Sc. (*Scalpellum*) *velutinum* Hoek, 1883, 40–2900 m.
Sc. (*Euscalpellum*) *bengalense* Annandale, 1906, 125–925 m.
Sc. (*E.*) *squamuliferum* Weltner, 1894, 180–2500 m.
Sc. (*Scalpellum*) *diota* Hoek, 1907, 200–1800 m.
Sc. (*Smilium*) *acutum* Hoek, 1883, 220–2220 m.
Sc. (*Scalpellum*) *longius* Annandale, 1913, 240–760 m.
Sc. (*Sc.*) *laccadivicum* Annandale, 1906, 250–1300 m.
Sc. (*Sc.*) *sociabile* Annandale, 1905, 290–450 m.
Sc. (*Sc.*) *pacificum* Pilsbry, 1907*a*, 400–2400 m.
Sc. (*Sc.*) *elongatum* Hoek, 1883, 550–1850 m.
Sc. (*Sc.*) *formosum* Hoek, 1907, 600–3550 m.
Sc. (*Sc.*) *lambda* Annandale, 1910*a*, 760–1200 m.
Sc. (*Sc.*) *gruvelii* Annandale, 1906, 790–2220 m.
Sc. (*Sc.*) *curimosum* Hoek, 1907, 790–? m.
Sc. (*Sc.*) *minutum* Hoek, 1883, 800–2700 m.
Sc. (*Sc.*) *novæ-zelandiæ* Hoek, 1883, 900–2800 m.
Sc. (*Sc.*) *wood-masoni* Annandale, 1906, 950–1650 m.
Sc. (*Sc.*) *elegans* Hoek, 1907, 950–1900 m.
Sc. (*Sc.*) *trapezoideum* Hoek, 1907, 1090–1570 m.
Sc. (*Sc.*) *alcockianum* Annandale, 1906, 1290–1800 m.
Sc. (*Sc.*) *annandalei* Calman, 1918, 1290–2220 m.
Sc. (*Sc.*) *abyssicola* Hoek, 1883, 2000–3800 m.
Sc. (*Sc.*) *albatrossianum* Pilsbry, 1907*b*, 3687–3775 m.

Remarks on the Distribution of the Cirripedia in the Arabian Sea.

Of the several localities in which Cirripedia were collected by the expedition, two, the Zanzibar Area and the Gulf of Aden, stand out as being especially favourable areas for these animals.

The Zanzibar Area has proved especially rich. The individuals from this region represent twenty species of the forty-three collected by the expedition. The following were found there:

Pœcilasma kæmpferi.
P. crassa.
P. excavatum.
Dichelaspis tridens.
Megalasma minus.
Heteralepas typica.
Scalpellum diota.
Sc. formosum.
Sc. laccadivicum.
Sc. lambda.
Sc. longius.
Sc. minutum.
Sc. velutinum.
Verruca murrayi.
V. sewelli.
V. capsula.
V. macani.
Balanus amphitrite communis.
B. albus.
B. echinoplacis.

In addition to these *Megalasma* (*Glyptelasma*) *hamatum* has been previously recorded from this area.

In all there were twenty-four stations in this area, at fifteen of which a net of some kind was used; seven were Petersen Grab stations, and two hydrographical. Hence there were only fifteen stations at which relatively rare animals like Barnacles could be hoped for in the catch, and that of these, eleven should yield one or more species is sure evidence of the abundance of these animals in this area compared with the rest of the Ocean. Sta. 106 proved exceptionally prolific, yielding five species—*Pœcilasma kæmpferi*, *crassa* and *excavatum*, *Dichelaspis tridens* and *Balanus echinoplacis*. Stations 122 with four and 109 and 115 with three each come next. Stations 105, 108, 110 and 118 each yielded two, and Stations 107, 111 and 120, one each.

The Gulf of Aden, while not so prolific of species as the Zanzibar Area, yielded the following thirteen species:

Lepas anserifera.
L. anatifera.
Pœcilasma excavatum.
Dichelaspis nierstraszi.
Oxynaspis aurivillii.
Smilium kampeni.
Scalpellum abyssicola.
Balanus amaryllis.
B. albus.
B. ciliatus.
B. thompsoni.
B. cymbiformis.
B. navicula.

While the frequency of Cirripedia is apparently still above the average in this area, they are by no means as abundant as in the Zanzibar Area, and only two species are common to both areas. Of eighteen trawling and dredging stations carried out in this region, seven yielded Barnacles. At some stations the species seem fairly abundant. Thus Sta. 24 yielded—

Smilium kampeni, *B. thompsoni*,
Balanus ciliatus, *B. navicula*,

and Sta. 27,

Pœcilasma nierstraszi, *Balanus cymbiformis.*
Oxynaspis aurivillii,

Sta. 194, which yielded a very large catch of animals, especially of *Puerulus angulatus* Spence Bate, yielded two Cirripedes, *Pœcilasma excavatum* (on the *Puerulus*) and *Balanus albus*. Sta. 35 likewise yielded two species, *Balanus amaryllis* and *B. cymbiformis*. The other three stations, 25, 39 and 185, each yielded one only.

It is interesting to note that the number of species of *Scalpellum* has fallen from seven in the Zanzibar Area to two in the Gulf of Aden, while the number of *Balanus* species has increased from three to six.

Going still further north along the South Arabian Coast the number of species obtained falls still lower. Out of seventeen trawling and dredging stations (two of them shallow-water motor-boat dredgings), only six yielded Cirripedes belonging to six species and one variety. Two others from this area belong to the littoral fauna of the Kuria Muria Islands. The greatest number of species was obtained at Sta. 54, which yielded two species, *Sc. elegans* and *Sc. wood-masoni*, and a new variety of the latter, *Sc. wood-masoni* var. *murrayi* nov. Here the frequency of the Cirripedes is much the same as in the other parts of the oceans—the animals are few in species and numbers. It is in this area, moreover, that large tracts occur practically devoid of animal life owing to the presence of sulphuretted hydrogen gas in the mud.

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